The Architecture of Learning™: Designing Instruction for the Learning Brain

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For Julia, my beautiful wife,

who possesses worthwhile insights

and unwavering faith
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Introduction

The Foundation: Defining Teacher and Designing Instruction

He greeted us at the classroom door—a tall, thin man with graying sideburns, bright eyes framed by dark-rimmed glasses, and a different colored sweater vest for each day of the week. His teaching led my ten-year-old mind through exciting worlds—outer space, amphibians, the water cycle, and the human digestive system. “What makes food travel down the esophagus,” he asked, “while we sit up at the table?”

Having just finished a unit on the Earth, we suggested that gravity pulls food down the esophagus while we sit up and eat. That seemed reasonable enough. After all, he had taught us the properties of gravity.

The next day he cleared a space at the front of the classroom. He reminded us of our gravity proposition and then called up a student. Placing a carpet sample on the floor, he asked the student to use the classroom wall for support while performing a headstand. On the floor he then placed a glass of water with an angled straw sticking out of the top and asked the student to take a drink. The student sucked on the straw, and we waited for the water to dribble out of his nose. But to our surprise, our fellow student swallowed that water! “Muscles in the esophagus push food downward to the stomach,” our teacher explained. “Gravity does not pull food into the stomach.”
He could have skipped the headstanding student and straw demonstration and just told us this fact. Yet he was prompting us to think in order to produce lasting learning. He designed an effective teaching lesson because he understood learning.

In contrast, a high school math teacher of mine, who also owned a large sweater vest collection, would leap from topic to topic, presenting disjointed concepts and skills like pieces collected from different jigsaw puzzles. Many of us frequently failed his tests, which we retook and corrected repeatedly until we “learned” the material. Though he knew his content, his teaching was ineffective because he did not understand the process of learning.

The term teacher implies learning. Dictionaries define teacher as an individual who causes another to learn something. If students do not learn, the teacher has been whistling in the wind.

Recent news headlines blazon the shortcomings of standardized test results. They accuse teachers of neglecting specific groups of students and announce state government takeovers of “failing” schools. What drives such accusations? A lack of learning. The public expects teachers to produce learning.

To be effective, a teacher must align instructional methods with learning’s cognitive processes, the brain’s ways of constructing understanding and forming memories. Although “teachable moments” do occur spontaneously, a good teacher
provides consistently effective instruction. Learning is produced through deliberate instructional design.

*Instructional design* differs from *lesson planning*, the term we traditionally use to describe a teacher’s pre-instruction preparation. Though *planning* implies forethought, *design* reaches beyond the standard plan. Designers communicate by intentionally combining elements. For example, technology writer Robin Williams claims graphic designers use four “interconnected” elements to convey ideas: proximity, alignment, repetition, and contrast.\(^1\) Similarly, teachers combine four elements to design instruction: an understanding of students, a knowledge of learning, an awareness of subject matter types, and a sequence of classroom activities that mirrors how the brain processes new data. Combining these elements requires more than traditional lesson planning; it requires instructional *design*.

You have probably had teachers who planned lessons but failed to design instruction. In my undergraduate days, I had a professor who carried a large three-ring notebook. When he opened that notebook and set it down on a lectern, class began. He “taught” by reading his notebook aloud while we tried to reproduce his treasured tome in our own notebooks. I cannot recall a single concept or skill I learned in that class. Even if “planned,” lessons read from lecterns limit learning because they fail to engage essential learning processes.
Contrast this with an effective learning experience. During those same college days I enjoyed a master teacher in an educational psychology course. This professor came to class with carefully crafted instruction, a distinct New Jersey accent, and enough energy to engage our attention. Group work, discussions, lectures, textbook reading—she designed every activity to optimize learning.

Such contrasting experiences illustrate an important principle: the quality of a teacher’s instructional design often determines the quality of a teacher’s instruction. Research confirms this: “Many breakdowns in student learning may be a function of poor classroom curriculum design,” suggests Robert J. Marzano in What Works in Schools. Informed instructional design produces effective teaching.

Designing instruction yields two outcomes that improve teaching. First, it deepens the teacher’s mastery of the material. Through thinking up a design, he identifies connections between the subject matter and personal experiences. These connections deepen his own understanding of the subject matter to be taught. Researchers Bransford, Brown, and Cocking stress the importance of this: “Expert teachers know the structure of their disciplines, and this knowledge provides them with cognitive roadmaps that guide the assignments they give students, the assessments they use to gauge students’ progress, and the questions they ask in the give and take of classroom life. In short, their knowledge of the discipline and their knowledge of pedagogy interact.”
Second, designing instruction engages a teacher in selecting effective methods and putting them in a logical sequence. “It is perhaps self-evident,” explains Marzano, “that more effective teachers use more effective instructional strategies.” Effective teachers produce learning that endures. Educators Diane Halpern and Milton Hakel explain that effective instruction is needed because as teachers, “we are teaching for some time in the future when the knowledge and skills that are learned in our classes are tested in contexts that we cannot know and with assessments that we cannot design. We need to provide an education that lasts a lifetime, which means thinking beyond the end of the semester, and let the learning principles for long-term retention and flexible recall guide our teaching practices.”

Teachers like my old elementary science teacher understand learning. Understanding learning improves instructional design. Improved instructional design generates better teaching. Understanding learning produces effective teaching.

A Note on the Author
I have been a teacher for more than twenty years, and I write from this perspective. My interest in neurocognitive research is a byproduct of my passion for enabling learning. I find learning, memory, creativity, and critical thinking especially intriguing topics, and I hope my findings in these areas have been accurately translated into tools for my colleagues.
Instruction can produce learning that lasts beyond the school year, learning that enriches the learner’s life. Students depend on teachers to possess the ability to teach what they know effectively. Hopefully, this book will enable all of us to design better instruction so we teach with greater effectiveness. I know my understanding of learning and ability to design instruction have benefitted from writing it.
Notes


4. Marzano, 78.

“All of the following words contain two vowels,” the puzzle-meister explained. While driving to church, I usually listen to the Sunday morning puzzle. “Simply drop one of the vowels to form a new word,” he continued. “Then replace the dropped vowel and drop the word’s other vowel to form another new word. For example, from feast you can form fest and fast. Ready?” I multitask, listening, thinking, driving and occasionally shouting answers. “The first word is wheat.”

“What and whet,” I shout. Too bad radio is a one-way audio experience.

Imagine you’re a passenger in my car on this particular Sunday morning. What words would you form from found? Remember, drop one vowel to form the first word. Then replace it and drop the other vowel to form the second word. (Answers: fund and fond.) Heard? (herd and hard.) Bloat? (blat and blot.) What a difference one letter can make!

I find the alphabet fascinating. Letters form the visual building blocks of words, and different combinations create different words. Altering a single letter can dramatically change meaning.

Like words, the process of learning contains building blocks that when arranged in various combinations foster different types of learning.
Learning’s Building Blocks

Five processes, or building blocks, interact to produce learning:

1. Experience
2. Comprehension
3. Elaboration
4. Application
5. Intention

Through experience, your brain gains raw sensory data. During comprehension, the brain sorts, labels, and organizes the raw sensory data. Through elaboration, the brain examines the organized data for patterns, recalls relevant prior experiences, and blends the new data with your experiences to construct understanding. During application the brain practices using the new skill knowledge. Finally, through intention, the brain uses the new understanding or skills in widened contexts.

Experience

We have heard the adage all our lives: “Experience is the best teacher.” By itself, though, experience is not learning. It does, however, play an essential role in learning: it provides sensory data to the brain. As an individual interacts with the environment, her nervous system relays data upward to her brain’s sensory registers. This data represents learning’s raw material.
The problem is, too much data in too little time overwhelms the brain. It registers a rapid flow of data, but the flood prevents the additional mental activity required for learning.

Let’s take a simple example. I enjoy roller coasters. Nothing makes me laugh like racing over looping tracks in connected cars with constantly changing stimuli bombarding my senses. “Wow, that was awesome!” I exclaim as the ride ends and I walk down the exit ramp. Friends who chose to “sit this one out” begin to inquire: “What made it awesome? How is this ride better than the one on the other side of the park?” Though I try, I cannot detail the ride’s sequence of thrills. At best, I might remember a few features (“The loop twisted upside-down!”) and an overall feeling (“It felt like I was floating!”), but the coaster’s details came too fast for my brain to do more than register their existence within the passing moment. My memory-forming processes had no time to engage.

Data floods of a similar nature occur in school. When I taught in a departmentalized middle school, I saw what I called the “seventh-period shutdown.” Students came to the day’s final class period looking like they had ridden six different 45-minute roller coasters. Each one, operated by a different teacher, bombarded them with new information, and the rising data flood overwhelmed their brains’ capacities to process it. I knew they would go home at night, sit down to dinner, and face the age-old
question: “So, what did you learn in school today?” They would give the inevitable answer: “Nothing.”

Did you ever own one of those banks that sorts coins? Experience resembles dropping coins into such a bank. If the bank had an exit hole that coins fell through before reaching the sorting section, the coins would be like experiences that the brain didn’t process. Data not processed is short-lived. Visual data lasts “only about a fifth of a second,”¹ and auditory data exhibits a similarly short life span.²

To learn, the brain must do more with the coins. “We often talk of knowledge as though it could be divorced from thinking, as though it could be gathered up by one person and given to another in the form of a collection of sentences to remember,” explains critical thinking expert Richard Paul. “When we talk in this way we forget that knowledge, by its very nature, depends on thought. Knowledge is produced by thought, analyzed by thought, comprehended by thought, organized, evaluated, maintained, and transformed by thought. Knowledge exists, properly speaking, only in minds that have comprehended it and constructed it through thought.”³ Learning requires mental activity. Raw experience by itself is not the best teacher.

If the brain grabs the coins and keeps them from a rapid exit, it can begin identifying and sorting the coins. It can begin constructing long-term memory. As Figure 1.1 shows, working memory, the brain’s systems that maintain “information in
short-term store for the purpose of executing a task-specific goal,“ is the gateway to long-term storage. Working memory holds the “coins” as the brain comprehends them.

![Figure 1.1 From Environmental Stimuli to Long-term Memory](image)

**Comprehension**

In the back of her closet, my mother kept a metal tin with a rose-covered lid that once held chocolates. She converted it to contain her extensive button collection. Some buttons had been pulled from childhood coats, others had their original display cards, and still others my mother discovered in parking lots and stairwells.

I loved sorting those buttons. I sorted them by size, shape, or color. I sorted them by the number of holes they had. I sorted them according to the type of clothing to which I imagined they belonged. I could classify those buttons in endless ways.

Imagine my mother’s collected buttons as incoming sensory data. During the comprehension stage, the brain assigns labels (e.g., “red,” “large,” “square”) and organizes data much as I sorted those buttons. In *This Is Your Brain on Music*, neuroscientist Daniel J. Levitin describes such processing as *feature extraction*: “The brain extracts basic, low-level features from the music, using specialized neural networks that decompose the signal into information about pitch, timbre, spatial location, loudness,
reverberant environment, tone durations, and the onset times for different notes (and for different components of tones).” In other words, the brain engages in comprehension, initially sorting music’s components much like I sorted buttons.

But how does the brain label and sort non-musical data? The primary tool that aids comprehension is language. We often talk to ourselves (at least inside our heads) when grasping new material. We use language both as a guide and as content for thinking. Researcher Diane Halpern describes thought and language as possessing “mutual influence,” stating, “We use language not only to convey our thoughts, but also to mold and shape them.”

Obviously not all thinking is language-based. But when we initially comprehend—label and sort—new data, we think with language.

Test this idea for yourself. Deliberately think through the information on experience detailed in the previous section. As you review Figure 1.1, you will likely initiate a mental monologue. If asked to portray your understanding in a visual form, you would likely develop a verbal explanation while creating the graphic. The process of creating the graphic could, in turn, spark additional ideas that you would initially process via words.

The actual words used for processing affect thinking. Experts Richard Paul and Linda Elder claim that a “command of distinctions” between terms shapes the content and quality of thought. A lack of terminology limits processing, and a lack of additional processing via working memory prevents the new data from being learned.
Consider the experience of self-confessed vocabularian Ammon Shea. Wanting to delay the sadness of reading a book’s last page, Shea decided to read one of the longest books available, the complete *Oxford English Dictionary*. Within its nearly 22,000 pages, Shea discovered words associated with known experiences for which he lacked terminology. For example, the scent that steams from pavement just as it starts to rain, he discovered, has a name: *petrichor*. Similarly, he discovered that having yellow teeth similar to those of some rodents makes one *xanthodontous*. Learning new terms such as these increased Shea’s thinking about the associated experiences and concepts.8 Knowing terms associated with a concept improves comprehension.

If repeated enough, comprehension can lead to low-level learning. For example, to merely memorize the Gettysburg Address, I would focus on restating the right words in their correct order. I can accomplish this by sequencing Lincoln’s phrases and rehearsing them until I can restate the entire speech. Such material entails merely semantic memory—“thoughts that require only memorization, but no decision making, logical analysis, or reasoning.”9

If I want to understand the Gettysburg Address—if I want to grasp the meaning of Lincoln’s words—so I can use it in the future, I must engage memory processes beyond comprehension. To build true understanding you must use “perceptual thought.” That is thinking that overlays the new data with known experience and blends the two to produce meaning.10 Your working memory must engage in elaboration.
Elaboration

First, let’s take a technical look at how working memory functions. It comprises four interacting components. The *central executive* functions as a “limited capacity attentional control system,” directing focus and concentration. The *phonological loop* holds and rehearses verbal and auditory-based information. The *visuo-spatial sketchpad* functions like the phonological loop, only with visually based information. The *episodic buffer* constructs “integrated representations” from new and recalled data.¹¹

While the phonological loop and visuo-spatial sketchpad aid comprehension, the episodic buffer goes a step further and empowers elaboration. The episodic buffer overlays patterns formed from newly organized sensory data with long-term experiences to construct understanding (Figure 1.2). Researchers Fauconnier and Turner’s term *conceptual blending* aptly describes episodic buffer activity.¹² The brain receives and sorts sensory data causing patterns to emerge. The patterns direct the brain to search its long-term memory stores for previous experiences that illustrate similar patterns. Daniel J. Levitin describes such processing as *feature integration*: “The frontal lobes access our hippocampus and regions in the interior of the temporal lobe and ask if there is anything in our memory banks that can help to understand this signal,” explains Levitin. “Have I [experienced] this particular pattern before? If so, when? What does it mean?”¹³ Once recalled, the previous experience provides a reference point for further thinking about the newly received data. According to Fauconnier and Turner, understanding develops as a person recognizes relevant connections between the...
reference point and the new data, and “blends” these ideas. The blend builds the new understanding.

Figure 1.2 New and Recalled Data Blends in the Episodic Buffer

As a child, I loved finger painting. My elementary art teacher would walk around the classroom giving each of us a single-colored dollop of paint. We’d dig in, spreading it across our papers in beautifully abstract arrays. Then she’d sweep by again, this time giving each of us a different-colored dollop. Now the fun really began! We’d press our fingers into the new paint and blend it with the old paint. As the new and the old blended, different colors would emerge. We could still see the two distinct dollops represented in our artwork, but we could also see blending that created a color that possessed characteristics of both dollops, but was also different.

During the process of elaboration, the brain examines comprehended (i.e., labeled and sorted) data to identify patterns, uses the patterns it recognizes to recall relevant instances from long-term memory, and overlays or blends the new data with
known experience. You mix the old dollop (previous experience) and a new dollop (new data) to create a new concept.

Film montage provides another useful analogy for conceptual blending. In *Three Uses of the Knife*, David Mamet explains:

Originally the term *montage* meant the juxtaposition of two disparate and uninflected images in order to create in the mind of the viewer a third idea, which would advance the plot. (A man who’s walking down the street turns his head and reaches tentatively in his pocket; shot of store window with a sign that says SALE; the viewer thinks, “Oh, that man would like to buy something.”) The first idea juxtaposed with the second idea makes the viewer—us—create the third idea.15

During elaboration, the mind merges incoming data (Image 1) with prior experience (Image 2) to construct understanding and meaning (the “third idea”).

Figure 1.3 shows the relationship between working memory, conceptual blending, and three of learning’s five building blocks: experience, comprehension, and elaboration. Experience provides new data, establishing the first component for conceptual blending. Comprehension sorts, labels, and organizes the new data. Patterns emerge and trigger recall of relevant past experiences. The past experience provides a reference point, the second component for conceptual blending. Elaboration continues as working memory systems blend the new data and the reference point to construct
understanding of the new data. When sufficiently processed, new data has a greater potential to reach long-term storage and, therefore, to be recalled and used.

Figure 1.3 Overlay of Working Memory, Conceptual Blending, and Learning Processes

I recently saw an ad campaign that illustrates these relationships. The television commercial opens with individuals enthusiastically singing “Old MacDonald” at the top of their lungs. Some sing operatically, some with a country twang, and some with a rhythm and blues flavor. All the while they are washing their hands. As the song’s final notes fade, an announcer explains that healthy hand-washing takes at least 20 seconds (new data), and that 20 seconds is about the length of time it takes to sing one verse of “Old MacDonald” (retrieved data provides a reference point). As the new idea of
healthy hand-washing’s time factor blends with the known idea of singing “Old MacDonald,” the viewer understands how long to keep washing.

If we could eavesdrop on a viewer’s brain as it processes the advertisement, we might hear the following (Figure 1.4): “Boy, these people sing ‘Old MacDonald’ with gusto! Why are they washing their hands while they do it? Hmm, healthy hand-washing takes a certain amount of time. I need to wash my hands for at least 20 seconds. What have I experienced that lasts about 20 seconds? ‘Old MacDonald’? Oh, okay, if I sing ‘Old MacDonald,’ it takes about 20 seconds. So, when I wash my hands I can sing a verse of ‘Old MacDonald’ to know how long to spend in the soap and water. I get it!”

I have only seen this advertisement once, but ever since I have been singing “Old MacDonald” in my head each time I wash my hands. *Elaboration makes material memorable and meaningful.*
**Figure 1.4 Hand Washing Commercial Processed to Construct Understanding**

While mental monologues aid comprehension, nonverbal thought often aids elaboration. Psychologist Steven Pinker claims, “To think is to grasp a metaphor.” He then offers an example that illustrates the relationship between elaboration, nonverbal thought, and understanding: The Declaration of Independence opens with, “When, in the course of human events, it becomes necessary for one people to dissolve the political bonds which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the laws of nature and of nature’s God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.” Pinker explains how the
blending that occurs during elaboration enables even children to construct understanding of the Declaration’s lofty concepts:

Children may not understand political alliances or intellectual argumentation, but they certainly understand rubber bands [as a reference point for political bonds] and fistfights [as a reference point for intellectual argumentation]. Conceptual metaphors point to an obvious way in which people could learn to reason about new, abstract concepts. They would notice, or have pointed out to them, a parallel between a physical realm they already understand and a conceptual realm they don’t yet understand. This would explain not only how children learn difficult ideas as they grow up but how people of any age learn them in school or from expository prose. Analogies such as THE ATOM IS A SOLAR SYSTEM or AN ANTIBODY IS A LOCK FOR A KEY would be more than pedagogical devices; they would be the mechanism that the mind uses to understand otherwise inaccessible concepts.\(^\text{17}\)

Increasing the variety of ways the brain processes information (e.g., both verbal and nonverbal) increases connections between new and known information.\(^\text{18}\) Learners deepen their understanding of new information by representing it in varied forms. Howard Gardner’s multiple intelligences (Table 1.1) offer one index of representational variety.\(^\text{19}\)
<table>
<thead>
<tr>
<th>INTELLIGENCE TYPE</th>
<th>IDEA REPRESENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>linguistic</td>
<td>ideas represented in spoken or written language</td>
</tr>
<tr>
<td>logical-mathematical</td>
<td>ideas represented numerically or in an analysis of “what has happened, and what may happen, under various scenarios” (p. 32)</td>
</tr>
<tr>
<td>musical</td>
<td>ideas represented through hearing or producing music</td>
</tr>
<tr>
<td>spatial</td>
<td>ideas represented in spatial organizations (e.g., flow charts, concept maps)</td>
</tr>
<tr>
<td>bodily-kinesthetic</td>
<td>ideas represented through physical stances and movement</td>
</tr>
<tr>
<td>naturalist</td>
<td>ideas represented in taxonomies of natural elements</td>
</tr>
<tr>
<td>interpersonal</td>
<td>ideas represented in characterizations, exploring individual’s distinctives, motivations, and needs</td>
</tr>
<tr>
<td>intrapersonal</td>
<td>ideas represented in self-awareness elements, such as “feelings, goals, fears, strengths, and weaknesses” (p. 39)</td>
</tr>
<tr>
<td>existential</td>
<td>ideas represented in “the biggest questions,” such as those found in “religious, artistic, philosophical, and mythic” system of thought (p. 41)</td>
</tr>
</tbody>
</table>

Table 1.1 Howard Gardner’s Multiple Intelligences

To prevent “newly learned material from slipping away, it needs to enter the network of the brain’s wiring,” explains neurologist and educator Judy Willis.

“Students can retain the new information by activating their previously learned knowledge that relates to the new material...Effective teaching uses strategies to help students recognize patterns and then make the connections required to process the new working memories so they can travel into the brain’s long-term storage areas.” To engage such thinking, a teacher can challenge students to represent new concepts in different forms. For example:
• How would the phases of the American Revolution sound musically?

• How would a model of the human ear look if constructed from students’ bodies?

• How could a mathematical process be represented in a cartoon?

Note what such tasks require of the learner. Significant connections between the new material (e.g., a mathematical process) and a nonverbal reference point (e.g., a cartoon) must be explored. For example, in representing phases of the American Revolution musically, the learner’s thinking may include answering the following questions:

1. What are the phases of the American Revolution?

2. What are each phase’s defining characteristics?

3. How can the defining characteristics be represented musically? What connections do I see/hear between the phase and musical expression?

The resulting connections, which stem from the student’s life experience, create a conceptual network that gives him greater flexibility in thinking. More connections increase such flexibility and widen the contexts in which the new understanding may be useful. For example, in the network structure illustrated in Figure 1.5, a series of connections that link musical symbols with increasing tension and ongoing sibling conflict may enable the individual to represent the conflict with musical symbols. Representing the conflict in this symbolic form may spark new solutions. The individual may then be able to approach the conflict in ways that lessen tension or even promote a calm outcome. “How can I move the conflict from its current forte state,” the
student may think, “into a state of less fury—into a mezzo-piano state?” The connections enable flexible thinking that influence responses.

Transforming the resulting representation back to words for explanation causes the process to start all over again. With each recurrence, understanding deepens, and deeper understanding produces learning that lasts.

Lasting learning can dramatically change a person’s perspective. In The Return of the Prodigal Son, the late Yale Divinity School professor Henri Nouwen relates the following anecdote: “A seemingly insignificant encounter with a poster presenting a
detail of Rembrandt’s *The Return of the Prodigal Son* set in motion a long spiritual adventure that brought me to a new understanding of my vocation and offered me strength to live it. At the heart of this adventure is a seventeenth-century painting and its artist, a first-century parable and its author, and a twentieth-century person in search of life’s meaning.” What was the network of connections that enabled Nouwen’s conceptual blending? A seventeenth-century painting and its artist, and a first-century parable and its author linked to a twentieth-century person. From these came significant results: a new understanding of his vocation and the strength to live it.

Elaboration leads to learning that is lasting, influential, and occasionally life-changing.

**Application & Intention**

Learning’s final two building blocks lead to active responses. Application, often called practice, allows a student to show her understanding within an instructional setting. For example, recall your experience of learning how to change a car’s flat tire. If you repeated the steps after watching a teacher demonstrate the process, you engaged in application. As you practiced, your teacher stood nearby and offered suggestions, such as “Don’t forget to loosen the lug nuts before jacking up the car,” and feedback — “That should be high enough.”

While practicing a skill is essential for mastery, moving to the application stage too quickly is a common mistake. Traditional math textbooks often illustrate this rushed pace. The left page features a brief explanation and a few examples (experience), and
the right page presents multiple practice exercises (application). Students are expected to perform the skill without going through the comprehension or elaboration stages.

Some teachers in other disciplines proceed similarly. For example, I once observed a middle school English class learning how to revise written drafts. The teacher defined *revising* for the students (“Revising means we reread our writing to make improvements”) and then told the students to go do it. He moved directly from explanation to application, never suggesting a how-to process or engaging the students in thinking that would enable them to devise a practical approach to revising. Such instruction skips the processes (comprehension and elaboration) that foster understanding.

The teacher should have identified a specific target for revision, such as using active rather than passive voice. For example, writing *Congress will pass the bill tomorrow* rather than *The bill will be passed by Congress tomorrow*. Then he could explain and demonstrate specific steps for making these revisions, such as: read the text sentence by sentence, identify any written in passive voice, and revise those sentences by making the subject perform an action.

Then students could record the steps on index cards and place them in sequence, as if creating a flow chart. The pattern illustrated by the steps—review, identify, and improve—could be related to experiences from the students’ lives, such as learning how to swing a bat: Revising for active voice is like learning how to swing a bat. In both you
review what you’ve done, identify what you’re doing wrong, and then make changes that improve the outcome. Sorting the index cards and connecting with past experiences help students understand they are using a process with specific steps that lead to better results. With a focus, the steps to address that focus, and an understanding based on their past experiences, the students are ready to practice. The teacher could provide paragraphs that the students revise as he stays nearby to offer review and redirection as needed. By leading students through experience, comprehension, elaboration, and application, the teacher equips students to use what they’ve learned with more independence and in wider contexts. He prepares them for learning’s intention stage.

A person uses intention when applying a new understanding or skill outside the classroom. Intention occurs in the “real world” when a similar incident prompts recall of understood concepts or relevant skills. For example, changing a truly flat tire, perhaps at an interstate rest area, or revising a manuscript for active voice, represent intention. The learner applies the skill outside of its instructional context.

Intention also empowers critical thinking. For example, imagine a student who, in tenth-grade social studies, constructs a firm understanding of America’s antebellum period leading up to the Civil War. As an adult, she reads about the cycle of conflict and compromise taking place in a country divided by racial or religious identity. Using the antebellum period as a reference point, she thinks, “This cycle cannot go on endlessly. Every compromise dissatisfies a large segment of the population. Either the sides have
to reach a final point of compromise or increased conflict seems likely.” Understanding this issue from the antebellum period enables her to make predictions. Depending on the circumstances, she may even be able to advise or take beneficial action in the case.

Unfortunately, intention rarely occurs. According to educator Eric Jensen, we see an “abysmal failure of students to transfer learning from school subjects to real life.” What contributes to a student’s ability to use knowledge in widened or varied contexts?

“The first factor that influences successful transfer is degree of mastery of the original subject,” conclude Bransford, Brown, and Cocking. “Without an adequate level of initial learning, transfer cannot be expected. This point seems obvious, but it is often overlooked…Transfer is affected by the degree to which people learn with understanding rather than merely memorize sets of facts or follow a fixed set of procedures [italics added].” If a teacher fails to engage students in comprehension and elaboration, the pattern recognition necessary for intention is less likely to develop. “It is important to be realistic about the amount of time it takes to learn complex subject matter,” explain Bransford, Brown, and Cocking. “Much of this time involves the development of pattern recognition skills that support the identification of meaningful patterns of knowledge plus knowledge of their implications for future outcomes.” Teachers who design instruction with all of learning’s stages produce learning that converts raw data into transferable knowledge.
Imagine a young adult with an interest in architecture. While in college, the budding architect sits in classes where knowledgeable professors present new, raw data. Returning to the dorm at the end of the day, he reviews the notes from the day’s classes and sorts the material, grouping and connecting ideas. This labeling and sorting causes patterns to emerge, which triggers recall of his summer job at a construction site: “Oh, cantilevers support that stairwell, just like the beams used in building that loft back in July.” As the past experience and the new data blend, the budding architect’s brain constructs understandings—insights erupt as new blends with known. Later, the student plans and builds a scale model of a building. During the process, the college professor offers suggestions and guidance, such as “Have you thought about a weight-bearing wall or other supporting option?” The student practices architectural principles by applying them within the classroom. Graduation arrives, and the newly educated architect travels to Europe. While there, certain buildings catch his eye, and soon he designs and oversees construction of original buildings inspired by those seen on the trip. The understanding constructed while in college empowers intention as the architect applies it in new and widened contexts.

Questions

1. In your own words, define each of learning’s building blocks: experience, comprehension, elaboration, application, and intention.

2. What relationship does working memory have to learning?
3. The author used letters and words to illustrate how building blocks in varying combinations produce different results. Identify a different illustration of this concept and explain it as a metaphor for learning.

4. In your experience as a student, what stages of learning are teachers most likely to neglect? What is lost when these stages are missing?
Notes


10. Ibid., 85.


14. Fauconnier.


17. Ibid., 241.


24. Ibid., 44.
Chapter 2
Power Tools: Learning’s Four Core Processes

Imagine four artists, each capable of producing a beautiful work, but there is a catch. Each can create a work of art only when all the others contribute their talents. Artist A can produce stunning results, but only when Artists B, C, and D contribute their talents to the effort. Likewise for Artists B, C, and D. These complementary artists have attempted working alone or with one or two others, but quickly discovered optimal results depended on a four-way interaction.

The core processes in learning reflect the complementary nature of this artist consortium. The five processes previously introduced—experience, comprehension, elaboration, application, and intention—interact to produce learning. The latter two, however, share underlying thought patterns that generate action. Application is employed within the instructional setting, while intention occurs outside the instructional setting. This leaves four cognitively distinct processes: experience, comprehension, elaboration, and application/intention. For efficiency, application/intention will be referred to simply as application.

Experience: Transforming Raw Data into Reference Points

Take a moment to recall a childhood experience. It might be the first time you stood at the end of a diving board. Maybe you won a spelling bee in fifth grade. Or you came in second because of one stupid word.
How many times throughout your life have you remembered that experience? Perhaps you frequently retell it to entertain others, consider it as you make important decisions, or recognize its influence on your perspectives.

All of these reasons to recall characterize one of my childhood memories. I grew up in a house with a large lawn that sloped dramatically. My father loved to mow the lawn, singing at the top of his lungs while maneuvering our yellow riding mower over hilly terrain. When I was old enough, he taught me to drive the mower and set me loose. (The singing, apparently, was optional.) On one side of the mower, a foot pedal controlled the clutch while the foot pedal on the other side controlled the brake. The previous spring, my father and older brother had proudly planted three apple trees in the backyard. While mowing, I suddenly found one of those trees directly in front of me. Panicking, I slammed my foot onto the wrong pedal, the clutch, freeing the mower to roll forward. On the slope, the mower gained speed, rolled over the tree, and sliced clean through its thin trunk. I thought my dad would kick me off the mower and never let me go near it again. But he laughed hysterically. “You should have seen your face!” he called across the yard. “Don’t worry,” he assured me, “that tree wasn’t healthy anyway. Now we don’t have to look out at a sick tree.” He stopped and pointed down at the mower. “Do you know which side has the brake?” I nodded sheepishly. “Okay, keep going,” he encouraged.
How many times have I thought of this incident? Too many to count. But if I never thought about that experience after it happened—if I did not consider its elements, how they fit together, the patterns they formed, and shared the results with others—my mental repertoire would lack this reference point. Through repeated recall, I have engaged learning’s core processes. I know the individual elements (dad, lawn mower, clutch, brake, sloped yard, apple tree) and how they connect (sequentially, cause and effect): comprehension. Those relationships reveal patterns—clutches free while brakes restrain, and mistakes, if treated properly, aid in learning: elaboration. By retelling the experience, I’m putting all that knowledge and understanding to use: application. I frequently share this story with students to help put their minds at ease about learning a new topic. “Mistakes will be made,” I explain. “We will make them, treat them lightheartedly, and then figure out where to find the brake.”

Can you trace your processing of a childhood experience similarly? What are the parts and how do they connect (comprehension)? What pattern does the experience illustrate (elaboration)? Can you retell the experience (application)? If so, that experience provides a reference point for thinking about related experiences or ideas. We can think of this processing as a sequence of thinking that focuses on the initial experience (Figure 2.1).
Comprehension: Transforming Data Into Knowledge

During the comprehension stage, the core processes identify and organize the knowledge gained during the experience, but that knowledge does not equal understanding or ability, as my high school basketball experience illustrates.

My coach was a patient man. I played basketball to be part of the team, not because I had any talent for the game. I had an understanding of defense, but I couldn't shoot. I remember my coach repeatedly working with me on my jump shot. I can still recite the steps involved:

1. Stand with your shoulders squarely facing the basket.
2. With your feet about shoulder-width apart, bend your knees while holding the ball just below your chin.
3. Hold the ball with your hand “cupped,” with only your fingertips touching the ball. Use your other hand to balance the ball in that position.
4. Jump, bringing your feet together and launching the ball upward and forward, and giving the ball a backward spin as you release it.
5. Follow through, flipping your wrist so that your fingers point toward the basket.

Even though I never mastered the skill, I know the steps I had to practice. How did these facts become part of my knowledge cache?
My basketball coach explained and demonstrated each step in isolation and then as a connected motion. In other words, he gave my brain the raw data for shooting a jump shot. As we sort and label the steps ourselves, we rehearse the facts and their relationships. We begin to construct knowledge. Notice I’m using the term knowledge rather than understanding. At this point, the knowing is confined to restating the facts and organizing them correctly. My coach asked me to restate the steps in their correct order. He asked me to engage in comprehension, labeling and sequencing the steps with my own words. I then moved on to the next step: elaboration. I remember thinking that a jump shot was somewhat like batting in baseball, a skill I could do. Both involved bent knees at the beginning, featured full body movement, and required follow through. By relating the two skills, I gained confidence in sequencing a jump shot’s steps. Application then deepens knowledge by initiating recall of the facts and their relationships. Every time we worked on the jump shot, my coach would have me retell how it was done before actually trying it.

We can think of this process as a sequence of thinking that focuses on comprehending important details of new data (Figure 2.2). Experience provides the new data that will be used to construct new knowledge. Comprehension provides the content and structure of the developing knowledge. Elaboration emphasizes the organization component of comprehension by relating similar previous experiences. Application engages the brain in recall of the labeled and sorted data.
Learning that does not proceed beyond comprehension prevents additional proficiency. For example, imagine a student in a high school algebra class who can recite the following: “To combine like terms, first identify sets of like terms for one side of an equation. Second, add the coefficients. Then simplify that side of the equation. Finally, repeat for the other side of the equation.” This student has labeled and sorted the data, but that does not equal understanding the concept of “like terms” nor the actual practice of combining them. Let’s say he has to simplify the equation 

\[ 3x + 8 + x = 30 - x + 11. \]

By doing the steps, he will reach: 

\[ 4x + 8 = 41 - x. \]

If the teacher rushes ahead into a new algebraic concept, the student’s knowledge of combining like terms will remain inert. He still needs sufficient processing to construct an understanding of like terms and practice to transform his understanding into using the new concept effectively.

**Elaboration: Transforming Knowledge into Understanding**

When the focus shifts to elaboration, the core processes interact to construct understanding. Elaboration makes the connections that generate *aha’s*. We have all seen the light go on in our students’ eyes. How can we make that process deliberate?
Remember non-electronic encyclopedia, those sets of books that seemed to hold the world’s collected knowledge? We were fortunate to have a set in my childhood home. They were pine green and cream-colored volumes with gold foil lettering on their spines. For me, the best pages in the entire set were the special acetate pages that showed the human skeletal system. Each partially transparent page could be laid on top of another. When you turned one acetate page, the body’s muscles fell into place, overlaying the skeletal system so you could see both. Flip another page, and the cardiovascular system appeared. Layer upon layer, you could build the human body from the inside out simply by turning pages. Connections could be seen, relationships identified, and interactions recognized. In the pre-computer age, it was technological magic!

Those acetate pages revealed how elements of the human body fit together, the patterns formed by muscle, blood, and bone, and they deepened the reader’s understanding of how the body’s structure and organization enabled its functions, such as movement and respiration.

We can think of this process as a sequence of thinking that focuses on constructing understanding (Figure 2.3). To continue the illustration, elaboration forms acetate pages out of new sensory data and past experience, allowing us to overlay and blend one with the other to discover connections. These discoveries weave organized facts into coherent understanding.
Figure 2.3 Core Processes Transforming Knowledge to Understanding

Newly gained knowledge, stemming from the comprehension stage, can be regarded as the first acetate page in the encyclopedia. Then you examine the second acetate page, noting the defining attributes of each. Elaboration blends both inputs to identify similarities, differences, and relationships between the new and the known; one acetate page overlays the other. The elements labeled and sorted during comprehension reveal their connections, and blending the new and known enables the brain to construct understanding of the new data.

Learning that does not proceed to elaboration and does not recognize patterns fails to make the connections that build understanding. For example, Miss Snyder takes her students on a special trip to the school cafeteria, where they follow the cafeteria manager to a room filled with stainless steel and conveyor belts. As they stand beside the industrial dishwasher, Miss Snyder explains that after they eat, their cafeteria trays are put through the dishwasher and then restacked for other students to use. The trays, explains Miss Snyder, make a big circle, moving into a student’s hands, holding food while the student eats, being washed and returned to the tray pile by the cafeteria entrance, and then being used again by another student. The tray changes somewhat with each step—sometimes being clean and empty, sometimes full of food, and
sometimes empty and dirty—but remains a cafeteria tray throughout. The students stand silent, riveted by these inner workings of the school’s gastronomic center.

Back in the classroom, Miss Snyder begins explaining the water cycle’s steps and sequence. She then asks, “Can you think of something we’ve seen that is similar to the water cycle?” Surprisingly, the students lack a response. They do not see what Miss Snyder desperately wants them to: like the cafeteria trays, water moves through a cycle, changing forms but always remaining water. To Miss Snyder, this relationship is clear and even helpful in understanding the water cycle, but the students struggle to recognize it and give an answer. How could they miss what she so clearly recognizes?

Connecting new sensory data and prior knowledge requires more than putting the two within cognitive reach of each other. The students did not understand the pattern illustrated by the cafeteria’s inner workings, and without an understanding of the intended reference point, they were unable to blend it with the new instructional material. The students’ awe never became an “Aha!”

During the elaboration phase, experience provides two inputs: one comprising newly organized sensory data (from comprehension) and one comprising relevant prior experiences pulled from long-term memory. Comprehension examines the two inputs independently, establishing the critical or defining elements of each. Elaboration, the focus process, overlays the two inputs to discover connections and construct
understanding. Application then uses the understanding to construct an explanation, and in so doing, often fosters additional elaboration.

**Application : Transforming Knowledge into Utility**

During the application stage, the core processes interact to develop an expression of understanding or to enable the mastering of new skills. Our “Oh, I get it!” inevitably leads to an explanation of what it is we understand. As we think through our understanding, we often discover new ways to blend the new and the known, continuing to construct deeper understanding of the new material.

These expressions often take the form of similes. “Oh, the earth’s structure—its core, mantle, and crust—is like an apple!” This use of figurative language makes sense given how elaboration functions. Two previously unrelated elements blend to construct new understanding.

Howard Gardner suggests that this blending, this search for connection, originates in childhood, which implies a natural inclination for constructing understanding through elaboration. As we age, Gardner suggests, our tendency to verbalize similes diminishes, but the tendency to think about and appreciate comparisons remains.¹ James E. Zull suggests such thinking connects the conceptual and the physical to promote understanding: “We cannot understand anything unless we create internal neuronal networks that reflect some set of physical relationships that accurately map the relationships in the concept” [italics added].²
Some material leads to a different form of application. Once a student knows the steps and understands the concepts that make up a new skill, she needs to try using the skill to achieve a result. Application provides the practice that constructs proficiency.

Unfortunately for my proficiency as a pianist, I grew up in an era of cool television and film theme songs. Who would want to practice four octaves of the B-major scale when they could play the theme from *Hill Street Blues*? As a result, I never mastered the fingering for scales.

My wife is an outstanding pianist and great teacher. When I became her student, she didn’t want me to learn new theme songs; she wanted me to learn the scales first. She set the music in front of me, and I immediately started to try playing the notes. “Wait!” she said. “Let’s take a minute to look at this scale. What key are you playing in? Look at the right hand score. What finger plays the first note? Between what two notes does your thumb cross underneath to allow you to smoothly finish the scale?” All these questions! She wanted me to think before I actually played the notes. She continued, “Does the fingering for this scale match the fingering for any scales you know?” Now she wanted me to put the new data together with previous knowledge. Once I recognized the fingering pattern as being similar to a previously mastered scale, she had me try the scale for the first time. Even though I would need practice to develop accuracy and efficiency, I played the scale much better on the first attempt than I would have without her thought-prompting questions.
Practicing new learning develops the ability to apply a skill accurately and efficiently. We can think of this process as a sequence of thinking that focuses on utilizing beneficial skills (Figure 2.4).

For example, if I understand the relationships of the components in an algebraic equation, I can find a solution for \( x \). But I need data to start with. My teacher presents me with the equation \( 4x + 3 = 23 \) (experience) and asks me to find the value of \( x \). I begin labeling and sorting the components (comprehension). I know that 23 represents the “answer” to the problem. I know that the problem contains a variable, for which I am trying to identify a value. I also recognize the mathematical processes within the problem: multiplication (4 times \( x \)) and addition (plus 3).

Now I explore relationships between those elements and compare them with reference points pulled from my long-term memory (elaboration). I remember in an equation, the “sides” are balanced; both have equal values. So, if remove the + 3 element on the left side, I must subtract an equal value from the equation’s right side (23 - 3 = 20). I also know that multiplication’s “opposite” operation is division. So, to find the value of \( x \), I could divide the “answer” minus 3 by 4 \([23-3]/4\). My
understanding of the relationships between the elements and my recall of relevant processes equips me to take action (application). I solve the problem: 20/4=5; x=5.

My thinking, focused on application, moves through the core processes to generate action. As I practice similar problems, my comprehension and elaboration processes shorten in duration to a point where I can act efficiently. Once I see the problem, I immediately know how to find the value for the variable. My understanding becomes utility.

**Emotion: The Propeller That Drives Learning**

Many educators hold extreme perspectives of emotion’s relationship to learning. Some see no room for feeling in teaching while others value sentiment over scholarship. We fight a covert war pitting facts versus feelings, not realizing that neither extreme aids learning. “When we educators fail to appreciate the importance of students’ emotions, we fail to appreciate a critical force in students’ learning. One could argue, in fact, that we fail to appreciate the very reason that students learn at all.”

Facts and feelings dance inextricably through our neurological landscape. “There is a place...where explicit memories of emotional experiences and implicit memories meet,” notes Joseph LeDoux, “—in working memory and its creation of immediate conscious experience.” Two neighbors in the brain, the amygdala and the hippocampus, contribute different inputs to two different memory systems. Sensory data channeled through the hippocampus is processed as factual, declarative data. New
data channeled through the amygdala is processed as emotional data. Our working memory blends both the declarative and emotional data, providing us with a unified experience. Once the experience is over, the emotional data often morphs into declarative memory.

For example, a fourth-grade student may remember the excitement of her first day of kindergarten. She may recall the newness of the experience, seeing her teacher for the first time, and the layout of the classroom. Even though she recalls the excitement of the experience, she does not respond as if she is again entering kindergarten. She is not excited by the memory.

Sometimes a memory’s emotional tag is dropped altogether. Can you remember anything emotional about learning that Earth is the third planet from the sun? For example, a child might be disappointed that it isn’t closest to the sun, but you probably had a minimal emotional response to the fact. Yet repetition of the information enabled your brain to retain the fact but lose any associated emotional tags.\(^5\)

However, the loss of memory can tip in the opposite direction. Emotional arousal tends to focus “attention on the ‘gist’ of an experience at the expense of peripheral details.”\(^6\) This process tends to be more common than memory of specifics. As a result, “our heads tend to be filled with generalized pictures of concepts or events, not with slowly fading minutiae.”\(^7\) And over time, the “gist” can devolve until only the amygdala’s contribution, the emotion, remains.
In my early elementary years, I suffered convulsions any time my fever reached a certain level. This caused my parents and my pediatrician great concern, so I was hospitalized for a series of tests. One of them still makes me react: the spinal tap. Even while I write this, I’m feeling hot and tingly and my breathing is shallow, as if I’m anticipating something terrible is going to happen. I cannot recall the details—Who was in the room? What time of day was it? Did it actually hurt? What did the results show? I do not know any of these facts, but I vividly recall the blazing fear. If anyone even mentions this medical procedure, my mind and body respond.

What does this mean for teaching and learning? Memory construction—and therefore learning—includes emotional data. In fact, *emotion drives and enables learning*. It focuses a student’s attention, allows her to find meaning, and feeds motivation.

*Emotion and Attention*

Emotion focuses attention for good or bad, as those of us who taught in the days following September 11, 2001, saw firsthand. Stress inhibits the additional processing necessary for learning. At the same time, an emotionally flat classroom also inhibits learning. Apathy is learning’s nemesis, and a teacher who ignores the power of emotion creates an atmosphere of inattentiveness.

The key lies in the Goldilocks principle: to foster learning, teachers must generate emotion that’s not too hot, not too cold, but just right. Too much emotion prevents new data from reaching the brain’s processing centers. Too little emotion ensures that
students will remain in a general, unfocused state of attention. A lack of focused attention prevents data from reaching the brain’s processing centers.  

Emotion contributes more to learning than just attention. It enables students to construct meaning and understanding. In determining how much energy to devote to new data, the brain asks, “Have I seen it before?” As the brain perceives that new data is connected to something it has previously experienced, it directs attention and energy toward constructing understanding of the new data. “Memory is enhanced by creating associations between concepts,” and those associations construct meaning. When it comes to learning, the brain’s motto is “Meaning before details.”

We need to engage students’ emotions to gain their attention and promote processing of new data. But what emotions should we emphasize? Do we want students on the verge of tears prior to introducing fractions? (Not advisable.) Do we need to generate pep rally-level excitement prior to engaging students in reading Hamlet? (Also not advisable.) What emotions enhance learning without overwhelming the brain’s ability to process new information?

Sustained Attention

The buttons were scattered on his desk, as one of my pupils bounced excitedly from foot to foot. “Look, Mr. W.!” he insisted. “See how these wires all lead into this thing here? That’s where the numbers must get added and stuff!” I had no idea whether or not he was right, but I recognized the thrill of discovery in his voice. Carson had
carefully—as carefully as ten-year-old hands allow—took his calculator apart. Every machine or machine-like object sparked his curiosity. “What makes it do that?” he’d often ask. I learned to say, “I don’t know, but I bet you can find out.” One day he came into my classroom with the dismantled handset from an old telephone in hand. “Check this out, Mr. W.” I’m not sure how much of the school curriculum Carson mastered that year, but I know how much he gained from his machine autopsies.

“Curiosity,” claims creativity expert and filmmaker Erwin McManus, “is essential for life. Curiosity is essential for learning.” Curiosity taps into the desire to know. It is what drives us to find answers, explore new things, and resolve contradictions. In short, curiosity focuses and sustains attention. What Carson personified in the extreme can, even in lesser doses, foster learning. How, then, can we spark student curiosity?

One way is to create a sense of mystery, keeping an unknown factor active in our students’ thinking while providing what is needed for them to make the “discovery.” This method works with everyone. For example, I recently led an in-service program for teachers. Writing instruction was our focus, and on the third day of the program we examined how to coach developing writers. The teachers came from a wide-range of levels, from kindergarten to college. To begin the morning, I gave each participant a wooden nut and bolt. I asked the teachers to hold the bolt by its head and position the nut at the bottom end. Then we turned the nut one full cycle, moving it slightly up the
bolt. We did this a few times before I asked the teachers to place the bolt on the table. I explained that we’d examine coaching as it related to writing instruction, and that I wanted them to think about what the nut and bolt might have to do with it. I began presenting the key concepts of coaching, pausing occasionally to allow the teachers to think about the nut and bolt. (Are you wondering what associations they made? If so, it generates curiosity even secondhand!) They entered into the discussion of coaching wanting to solve the “mystery”: What does this nut and bolt have to do with coaching? That sense of not knowing—of wanting to discover what someone had challenged them to find—focused and sustained their attention. When the group recognized that the bolt represented expectations and the nut represented coaching, they solved the mystery: cycles of coaching around consistent expectations generate upward movement or increased achievement.

Curiosity carries learning forward. Neurologist and teacher Judy Willis explains that such approaches provide just the right amount of challenge (not too hot, not too cold) to engage the amygdala at levels that “enhance the speed and efficiency of information flowing through into the memory storage areas of the brain.” Such “just right” stimulation, combining students’ curiosity with new instructional material, engages their emotions and sustains their attention.

Judy Willis also shares an excellent example of mystery-sparked curiosity that even had her wondering about associations. Hoping for ways to energize the next day’s
math lesson for her middle school students, Dr. Willis visited a supermarket, seeking an inexpensive item she could display on the students’ desks as they entered the classroom. She settled on a small vegetable, not knowing exactly how she would use it. The next morning, Dr. Willis started teaching the lesson without explaining the radishes the students discovered on their desks. At the lesson’s conclusion, the students asked about the radishes. Still uncertain of the answers, Dr. Willis replied, “Why do you think I put a radish on your desk for today’s lesson?” The students offered several explanations. They connected mathematical concepts with their sensory experience of the radish, making associations that seemed sensible to them. Though Dr. Willis could have “come up with something” to share as an explanation, the students’ thinking generated more connections, and their discovery of these connections fostered deeper understanding and better memory formation. In short, the students were engaged in significant elaboration of the day’s mathematical content prompted by its curiosity-generating pairing with a common vegetable.\textsuperscript{13}

\textit{Motivation}

As Dr. Willis’ experience demonstrates, motivation drives the best learning. Yes, you can learn the multiplication tables under the threat of punishment or to “earn” that blue ring. But both the stick and carrot produce learning that tends to stop once the threat is avoided or the prize is obtained. Authentic learning requires a motivated learner.
“Motivation is the director of emotions.” explains John Ratey. “It determines how much energy and attention the brain and the body assign to a given stimulus.” While generally not considered an emotion, motivation “ties emotion to action.” Our emotional response to a given stimulus generates the actions of our mind and/or body. For example, I’m a music lover. My mp3 player features performances from a wide variety of musical genres. My internet web browsers hold several bookmarks for sites that tell me when new recordings are coming out. I enjoy music even more when I know something about the artist, so I read anything I can find about my favorites. I am emotionally connected to music. My positive emotional response motivates me to take action—to read about music and musicians, to find new recordings (and sometimes vintage ones), to seek new artists whom I might enjoy. I do these things because my emotions propel me to act.

However, motivation generates more than activity. I also think deeply about music. I take pride in recognizing such details as a time signature change right when the lyrics take a new turn. Motivation generates the close listening, even though this process is more cognitive than concrete.

How can we motivate learners? If we use emotion to gain and direct their attention, how can we keep them advancing through the process of learning?

Here’s one helpful principle: meaning is motivational. Because the brain constantly strives to make sense of the sensory data our experiences provide, finding
meaning triggers the brain’s reward system and increases the likelihood of our retaining the information. “The brain’s determination of what is meaningful and what is not is reflected not only in the initial perceptual processes but also in the conscious processing of information,” claims Patricia Wolfe. “Information that fits into or adds to an existing network has a much better chance of storage than information that doesn’t.”

The brain is admirably designed to integrate new data with previous experiences. Association cortices, specialized regions spread throughout the brain, provide the bottom-up and top-down processing that empower perception. The bottom-up processing involves perceiving the data and “reporting” findings. For example, the crossing of two short lines is “reported” as the letter x. Once recognized, the new data gets top-down processing: the brain constructs associations between the new data and relevant previous experience.

Comprehension mirrors the brain’s bottom-up processing, and elaboration represents its top-down processing. Instruction that capitalizes on this natural neural functioning motivates learning.

Transfer

Emotion’s influence does not stop with the initial stages of learning. Research findings suggest that “emotional processes are required for the skills and knowledge acquired in school to transfer to novel situations and to real life,” claim Mary Helen Immordino-Yang and Antonio Damasio. “That is, emotion may play a vital role in
helping children decide when and how to apply what they have learned in school to the rest of their lives.” Emotion acts as a “rudder” in decision-making and reasoning. It enables the learner to use known content and skills in addressing the real world. Emotions act “like shelves,” providing “…a repertoire of know-how and actions that allows people to respond appropriately in different situations,” note Immordino-Yang and Damasio.\(^{17}\)

Emotion influences every phase of learning, from raw experience through application and intention. Overlaying emotion’s contributions and learning’s core processes reveals complementary interactions (Figure 2.5). Through experience, emotionally interesting data engages our senses; it gains attention. That attention gains focus as we comprehend—label and sort—the defining attributes of the new data. As we engage in elaboration, we construct understanding and discover meaning of the labeled and sorted data. Finally, as we use our understanding, we respond to circumstances with know-how. And, if truly engaged in learning, curiosity drives us forward through the core processes. Learning and emotion are complementary processes.

![Figure 2.5 Core Processes and Emotion](image)

*Figure 2.5 Core Processes and Emotion*
Questions

1. Explain how the artists introduced in the chapter’s opening produced their best artworks.

2. List the core processes. Why are application and intention combined in the core processes?

3. Relate the artist allies to learning’s core processes. How do the artists’ interactions illustrate those of the core processes?

4. What does a focus on each of the following core processes produce? What role does each product play in learning?

   experience

   comprehension

   elaboration

   application

5. Re-examine Figure 2.7 and explain the relationship of emotion to learning’s core processes.
Notes


5. Ibid., 170-173.


7. Ibid.


10. Ibid., 84.


16. Medina, 204-205.
A few years ago, my wife and I pursued the dream of building our own home. Julia ventured into a subdivision one day and called me via cell phone. “I’m not sure I know how to get home,” she laughed, “but I’ve found where we want to build a house!” She had driven into a wooded subdivision set atop a large hill, and once I saw the site, I agreed with her. Our building adventure began as we purchased the lot, started reading about home design, and collected photos that fit our vision.

Having a blueprint developed proved critical in the construction process. While we could communicate directly with our builder regarding stylistic elements such as paint color, we needed the house to be framed soundly and function properly. The blueprint provided the needed direction.

Before we could give the architect the information needed to design the blueprint we had to answer some questions:

1. How do you want to live in the home? What functions will each room have?
2. What underlying feel do you want the home to have? What ideas/sensations/experiences do you want?
3. How do you want the rooms to connect? How do you hope to move within the space?

The answers to these questions would influence the content and cohesiveness of our home’s design.
Designing instruction requires answers to similar questions:

1. What will your students be learning? What will they do with their learning?

2. What pattern(s) support(s) the instructional material? How will that/those pattern(s) connect to your students’ prior experience?

3. How will you focus your students’ attention and engage the mental processing needed to construct the learning? How will the flow of instruction mirror the brain’s means of learning?

The cognitive steps—experience, comprehension, elaboration, application, and intention—interact to construct the timbers of learning. An effective teacher engages these processes, *but not in equal measure*. The subject matter being taught influences which phases are emphasized. Just as a construction blueprint guides home building to a predetermined outcome, an Architecture of Learning™ Blueprint guides teaching that produces true learning. By using the Blueprint as a template, the teacher can align subject matter types with their required cognitive processes.

A teacher begins designing effective instruction by first examining the subject matter and answering the related questions: What will your students be learning? and What will they do with their learning?

**Discerning the Difference: Skills**

“I don’t get it! I can’t identify them.” Jaime’s frustration began during the practice exercises and peaked as the class ended. “If this is what’s on the state test I might as well quit right now. I’ll never pass it!”
I met Jaime while teaching remedial reading at a community college. Most of my students, like Jaime, had graduated from high school even though they possessed only middle-school reading abilities. Their eventual acceptance into college-level classes depended on their passing three levels of remedial reading. I taught the lowest level. To complicate matters, what they achieved in my class didn’t influence their grades. Passing or failing depended entirely on a standardized state test they took. Several of the test’s questions required the student to identify the main idea of a text passage, the very skill Jaime found so difficult.

“Okay, Jaime,” I began, “let’s go over it one more time—”

“That won’t help,” Jaime interrupted. “I can repeat your explanation word for word, but I still can’t find the main idea!”

I suggested we try working through a short paragraph together. After Jaime read it, he could tell me the paragraph’s topic, yet asking for more information triggered the comment: “I don’t know how to find anything more than that.” This revealed the real problem: I had taught what the required textbook suggested—the definition of main idea—but I had not given my students a strategy for identifying main ideas. Without a step-by-step process, Jaime lacked the knowledge needed to pick them out.

I began with what Jaime could do. “Okay, you can tell me the topic—who or what the paragraph is about. You’ve got one piece of the puzzle,” I explained.

“Identifying the main idea requires two more pieces. What facet of the topic does the
paragraph discuss? And what does the writer want you, as the reader, to know about that facet? Let’s try this. You said the paragraph is about Mark Twain.” Jaime nodded in agreement. “What part of Mark Twain’s life is this paragraph about?”

Jaime scanned the paragraph again and said, “It’s about his writing.”

I smiled encouragingly. Two of the three pieces were in place. “Now, what does the writer want us to know about Mark Twain’s writing?”

“Well,” Jaime replied, “it talks about some of the stories he wrote, but that doesn’t seem like what she wants us to know. I think she wants us to know that Mark Twain was funny.”

“Great, Jaime!” I felt like we were on the brink of a breakthrough. “Now, take the three pieces—Mark Twain, his writing, and being funny—and put them into a statement.”

Jaime hesitated, thinking. “Mark Twain’s writing was funny?” It wasn’t quite “Humor characterized Mark Twain’s writing,” but it was progress. I asked Jaime to restate the three “pieces” we had used (who or what, what facet, and what about it we should know). I wrote these in Jaime’s notebook, and we worked through a few more examples. Jaime left equipped with a strategy for identifying main ideas. Even better, in the next class session, Jaime presented the strategy to the entire class. Immediately, students who had been struggling began identifying main ideas with increasing
success. Jaime would go on to master the skill and pass the required standardized test. He just needed the right steps.

Students learn a skill when they master a series of steps to efficiently accomplish a goal. That can be skipping, forming the letter a, or identifying main ideas. The student reproduces a specific sequence of steps, develops proficiency through practice, and applies the skill as needed in real-world interactions.

Accuracy and efficiency characterize skill proficiency. For example, elementary physical education instructors often teach students overhand throwing. The skill includes the following steps:

1. Stand with your side to the target.
2. Place the ball in your back hand.
3. Hold out your arms, forming a T while lifting your opposite foot.
4. Step with your opposite foot while bringing the ball over your head.
5. Release the ball and follow through by “scratching” your opposite knee.

Skills do not have to be physical. Reading comprehension, for example, requires several cognitive skills. A cognitive skill comprises a series of thinking steps that accomplish a goal. For example, when teaching students how to recognize cause and effect within a text, a teacher may outline a series of thinking steps, such as:

1. Identify what happened.
2. Consider what made (i.e., caused) that to happen.
3. State the relationship.
The teacher may then read aloud a story featuring cause and effect relationships and demonstrate the skill’s steps. Eventually, during practice, students reproduce the thinking steps demonstrated by the teacher. Although the product—better understanding of a text—is achieved through cognitive rather than physical activity, the series of steps that accomplishes the task makes recognizing cause and effect a cognitive skill. Proficiency in applying this skill improves reading comprehension.

Making a skill second nature can be critical. Imagine a child playing in a softball game when an opposing team member hits a ball past the infield. If she pauses, thinking, “To throw, I must stand with my side to the target and the ball in my back hand, bring my throwing hand up and back, forming a T. Now I must step with my opposite foot…” the batter may take an extra base, and the coach may be shocked speechless. Instead, the outfielder needs to return the ball to the infield immediately; she needs to apply the skill of overhand throwing automatically.

Yet overhand throwing merely requires a level of proficiency where it is done “without thinking.” Application of some skills require a refined method of thinking. Throughout the semester, my community college students worked on several reading comprehension skills, such as the one Jaime mastered: identifying a text passage’s main idea. Ideally, I wanted the students to recognize main ideas without deliberately proceeding through the steps. Stopping after every paragraph to ask the questions, identify the answers, and assemble a statement negatively influences reading rate.
During *initial* practice, the students benefitted from systematically working through the steps. As they gained proficiency they also became more efficient, relying less on the deliberate three-step process. However, they could still use the strategy when a passage proved to be difficult.

Revising one’s writing also uses skills that are open-ended. For example, revising modifiers requires that a student immediately know *what* to do, but *not* necessarily how to do it. Recognizing a modifier can be done quickly, but making a choice to keep or eliminate the modifier is not done “without thinking.” That’s not to mention the third option: changing the modifier to one that describes the noun better.

Regardless of differing forms, skills always feature a series of steps that produces a desired result—the ball gets thrown, the main idea gets identified, the sentence gets revised. Once a possible skill is identified, a teacher has to design the instructions on how to use it. He considers questions regarding the skill’s pattern(s):

1. What pattern(s) support(s) the instructional material?
2. How will that/those pattern(s) connect to your students’ prior experience?

By identifying a skill’s pattern, the teacher can establish a reference point that fosters understanding in his students and helps them use the new skill.
Skill Patterns

The brain seeks patterns so it can recall relevant prior experiences to construct understanding. Prior memories help students think about how to address new circumstances. During instruction, students connect new skills and previous experiences that feature similar steps, similar concepts, or both. Skills often illustrate patterns in their series of steps.

For example, teachers in most disciplines want students to master the skill of citing and listing references. Structure and thoroughness characterize a well-referenced report or paper. The teacher plans to teach how to form in-text citations and end-of-text reference lists. Depending on the selected style (e.g., MLA vs. APA), the teacher presents the order, capitalization, and punctuation involved. This provides the students with a series of steps. For example, in developing the reference list, some of the steps involve finding a book’s author’s last name, first initial(s), the year the book was published, and the complete title. When generalized conceptually, this skill illustrates the relationship of completeness and credibility. For example, students may see this relationship represented by comparisons of completion and quitting. The teacher may ask if they’ve ever seen an athlete quit or give up before a competition was over. From the examples the students identify the labeling and sorting of the characteristics of quitting too soon vs. completing the competition, and the discussion of how reliable or credible an athlete who gives up is (or is not), a pattern begins to emerge: completeness adds credibility.
Sometimes a more literal generalization works better. For example, science teachers want students to learn how to draw conclusions based on the results of an experiment. The steps for such a skill may include:

1. Conduct the experiment as directed.
2. Review in detail what happened during the experiment.
3. Review the results.
4. Ask, “How might the elements of the experience and the result relate?”
5. State your best, most supportable answer.

When generalized, these steps illustrate a simple pattern: observe, review, and conclude. Many experiences, such as viewing a series of photographs taken moments apart, engage students in illustrating the pattern. They review the events each photo shows, and conclude what happened to produce the results shown in the final photo. Such an experience provides reference points for understanding how to draw conclusions from experiments.

The brain can identify more connections to a pattern that is both common and succinct. The more connections the brain makes between the new material and prior experiences, the deeper the understanding it can construct of the new material. By recognizing a skill’s underlying pattern, stating it succinctly, and providing a common experience that illustrates that pattern, the teacher activates a student’s relevant prior knowledge to aid new learning.
Identifying Patterns:

**SKILLS**

1. Identify the skill’s individual steps
2. Generalize the steps by removing context-specific terms
3. Rephrase the resulting sequence into a pattern statement

**Figure 3.1 Steps for Creating Skill Pattern Statements**

**Blueprint Structure**

**Strands**

Once the subject matter is recognized as a skill and its pattern is identified, a third set of questions guides the teacher in designing how to present it to the class:

1. How will you focus your students’ attention and engage the mental processing needed to construct learning?

2. How will the flow of instruction mirror the brain’s means of learning?

To teach a student a new skill, a teacher needs to focus on four processes:

skill learning = **EX**perience + **CO**mprehension + **AP**plication + **IN**tention.

The initial **EX**perience should contain a pattern-based reference point for understanding a skill’s steps (e.g., finding a paragraph’s main idea is *somewhat like* putting together a three-piece puzzle). **CO**mprehension provides the required knowledge and the steps required to learn the skill (e.g., first, determine who or what the paragraph is about…). Because skills must be mastered, students consume significant instructional time developing accuracy and efficiency through practice. **AP**plication uses the new skill over and over. **IN**tention provides widened contexts for students to apply the skill.
Because the focus of these four processes is to build students’ skills, they form the rows, or “strands,” of the Architecture of Learning™ Skill Blueprint (Figure 3.2).

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>contains a pattern-based reference point for understanding a skill's steps</td>
</tr>
<tr>
<td>Comprehension</td>
<td>provides the required knowledge and the steps required to learn the skill</td>
</tr>
<tr>
<td>Application</td>
<td>engages students in practicing new skills to develop accuracy and efficiency</td>
</tr>
<tr>
<td>Intention</td>
<td>provides widened contexts for students to apply the skill</td>
</tr>
</tbody>
</table>

*Figure 3.2 Architecture of Learning™ Skill Focus Processes*

**Cells**

The Skill Blueprint’s strands in turn intersect with learning’s four core processes—experience, comprehension, elaboration, and application—which form the Blueprint’s columns. These intersections form *cells*. Each cell identifies the appropriate *core process* for that step of the strand. For example, the first strand, Experience, and the first core process, experience, intersect to create the Blueprint’s first cell, referred to as EX-ex.

Moving sequentially, the Experience strand intersects with the remaining core processes: comprehension (forming the EX-co cell), elaboration (forming the EX-el cell), and application (forming the EX-ap cell). Once instruction flows through the Experience strand, it then moves into the Comprehension strand, the Application strand, and the Intention strand (Figure 3.3). Like the Experience strand, these intersect with the core processes to form cells. Each strand, therefore, comprises four cells. Let’s see how this framework guides the design and delivery of instruction.
Designing Skill Instruction: An Example

The Skill Blueprint’s influence on designing instruction can be seen from the very beginning of the process.

*What will your students be learning? What will they do with their learning?*

After considering how to teach students to revise writing by eliminating nonessential modifiers, Marcus, a middle school teacher, first recognizes the subject matter as a skill. It consists of a *series of steps*—a process—students will use to improve the quality of their writing.

Learning the new skill can be broken into four steps:

1. Identify the modifiers within a sentence.
2. Consider the word(s) each modifier describes.
3. Consider whether the modifier repeats the meaning of the targeted word or adds significant meaning to it.
4. If it repeats the meaning, eliminate it. Or, on the flip side, change the targeted word so the modifier can be eliminated. If the modifier in fact clarifies the intended meaning, keep it.

What pattern(s) support(s) the instructional material? How will that/those pattern(s) connect to your students’ prior experience?

Generalized, these steps might be:

1. Identify the item to consider.
2. Examine its relationship to its target.
3. Keep what is needed but eliminate the rest.

The pattern begins to emerge when Marcus phrases these steps more efficiently:

Find it. Consider its relationships. Choose an effective action. By thinking about the steps in broader terms, Marcus identifies the skill’s underlying pattern. He reduces the pattern to its imperatives: Find, consider, and choose.

Once the pattern has been stated, Marcus begins designing instruction based on the Skill Blueprint.

EXperience Strand

How will you focus your students’ attention and engage the mental processing needed to construct the learning? How will the flow of instruction mirror the brain’s means of learning?
Each cell within the EXperience strand (Figure 3.4) advances the students toward establishing a reference point for learning the new skill. The EX-ex activity illustrates the pattern previously identified by the teacher.

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**Figure 3.4: EXperience Strand General Descriptors**

To teach students how to revise writing by eliminating modifiers, Marcus begins with an activity that illustrates: *Find, consider, and choose.* What if, he thinks, I gave students a box of items and told them to use the items to construct an airplane that could fly across the room? Students would *find* items and *consider* each one in relation to the goal and to the other available items. They would then *choose* to use some items and eliminate others. This illustrates the pattern, he decides, so he makes it the EX-ex activity.

Before his students recognize the pattern, they must comprehend the experience. Instruction moves into the EX-co cell, where the teacher guides student review and
sorting of the experience. While student activity may be effective here, teacher-directed questioning and discussion often produce optimal results.

After his students have constructed the planes, Marcus asks them, “What just happened? What were the steps you took?” As Marcus guides the discussion, students articulate the experience in sequence:

1. We received a box of items.
2. We used some of the items to complete a task.
3. We had some items left over.

Marcus continues engaging student thinking with additional questions: “How did you decide which items to use? Did any groups use items that other groups left out of the finished product? Were any items chosen at first but then refused? Why weren’t they used?” This questioning prompts the students to mentally organize the experience rather than Marcus reviewing and organizing it for the students.

Like EX-co, the next cell, EX-el, directs the students’ attention back to the illustrative experience (EX-ex). A combination of questioning, contemplating, and conversation often helps them to elaborate.

Marcus asks, “Can you see any patterns emerging from building the airplanes?” With continued questioning and guidance, Marcus leads students to “discover” the pattern. (Occasionally, the teacher needs to explicitly state the pattern.) Students then discuss and explain how the experience illustrates the pattern: Find, consider, choose.
Students expand and use their understanding in the EXperience strand’s final cell, EX-ap. To enable students to recognize personal illustrations of the pattern, Marcus restates the pattern in a flow chart (see Figure 3.5). Students then use their understanding of the pattern to identify illustrations from their own backgrounds. They can then organize these personal experiences into flow charts, replacing the pattern’s steps with personal examples of something found, something considered, and something decided or chosen. These personal reference points provide several potential connections for students to construct an understanding of how to revise writing by eliminating modifiers.

![Flow Chart](image)

*Figure 3.5 Pattern Presented in Flow Chart (EX-ap)*

For example, the students may relate the pattern to packing for a vacation. If the plan is to spend time at the beach, heavy sweaters and winter coats do not need to be packed even though they are normally found in the student’s closet. Considering the relationship of the destination to the article of clothing reveals what is and is not needed.

As you move through the four core processes, the EXperience strand flows like a single activity (Figure 3.6). Comprehension, elaboration, and application direct the
students’ attention to a personal experience that illustrates the pattern and establishes it as a reference point. Instruction then moves into the COmprehension strand.

![Diagram of the COmprehension strand]

**Figure 3.6 Unit EXperience Strand**

**COmprehension Strand**

The COmprehension strand covers the skill’s “how to” information. The teacher presents and models the skill’s steps (CO-ex), helps students state and reorganize them (CO-co), guides students to recognize connections between the new skill and the previously established reference point(s) (CO-el), and engages students in initial, guided practice of the new skill (CO-ap) (Figure 3.7).
**Figure 3.7 COMprehension Strand General Descriptors**

In CO-ex, the teacher presents the new skill, listing its individual steps and demonstrating how one follows the other. *Simply telling students the steps is insufficient for mastering a skill*. The skill’s steps *must be modeled by a teacher*, both in isolation and as a complete process, so students can accurately replicate them. Students need to “do” the skill. Demonstrating *how-to* fosters learning to do.

This may be because demonstration actually encourages the brain to engage. Specialized neurons known as *mirror neurons* make practicing “in the head” possible. Neurologist Richard Restak details an example that explains how mirror neurons function:
[A] perception-action matching system exists in the human brain. Imagine yourself watching me reach out and grasp the cup of tea that now sits on the small table next to my word processor. As you observe my hand reaching for the cup, the motor cortex in your brain will also become highly active in the same areas you would use if you reached out to pick up that teacup...No, that doesn’t mean you can taste my tea. But it does mean that I’m directly affecting your brain as you watch me go through the motions of drinking my tea...Think for a moment of the implications of this. You can activate my brain if you can attract my attention enough to get me to watch what you’re doing...

When a teacher repeatedly performs a sequence of steps, her students’ mirror neurons may enable their own preliminary practice of the same steps. In other words, as a teacher demonstrates a skill, students mentally rehearse it.

For example, Marcus introduces the steps for eliminating modifiers, explaining and demonstrating each step thoroughly. He then thinks aloud as the skill’s steps are used to improve several examples. He does not call on students for their input yet. Instead, he explains and performs the process to all of his students:

I have a paragraph here on the board. I’m going to revise it by working through it sentence by sentence, checking my modifiers and making improvements wherever I can. The first sentence reads, “Ellis Island, the first entry point for many traveling immigrants, lay within sight of New York City.” The first step I
want to take is identify the modifiers. I’m going to underline them as I find them. I see *first*, *entry*, *many*, and *traveling*. Now, for step two, I need to consider the words in the sentence that these modifiers modify. The modifier *first* modifies *point*. The *first point* for immigrants. That doesn’t really make sense. The first point of what? Oh wait, my next modifier is *entry*, and it also modifies *point*. The *entry point* for immigrants. If it is the entry point, it has to be the first part of the United States that the immigrants encounter, right? So, it seems like *first* repeats the meaning of *entry*, and *entry* seems like a clearer modifier for *point*. So, I’m going to eliminate *first* but keep *entry*. Now my next modifier is *many*…

Demonstrating the skill, as Marcus does through thinking aloud, moves instruction naturally toward application. Before practicing the skill though, students need to review and sort its steps as the teacher demonstrated.

In the CO-co activity, referring students to the flow chart they created in the EXperience strand (EX-ap), Marcus has students create a similar flow chart, first detailing and then illustrating the skill’s steps (Figure 3.8). This engages students in visualizing and organizing the skill, and it provides an opportunity for a teacher to assess each student’s knowledge. Who identifies the steps and orders them correctly? Who needs additional instruction, demonstration, or guidance? Who seems confused by one or more of the steps? Marcus keeps these questions in mind as he moves around the classroom and observes the students’ work.
Marcus engages his students in comparing the flow charts developed during the EXperience and COmprehension strands by completing an open-ended sentence:

“Revising writing by eliminating nonessential modifiers is like the airplane assembly experience because...” To foster individual thinking, Marcus has the students write down their initial responses first before sharing and discussing them. To strengthen connections between the new material and meaningful reference points, Marcus directs the students to examine their personal examples developed during the EXperience strand (EX-ap), identify one or two that relate to the skill, and explain their connections:

“My experience of ____ is like revising writing by eliminating nonessential modifiers because...”

In the strand’s final cell, CO-ap, students initially practice the skill with their teacher providing guidance and immediate feedback to ensure accuracy. This is not an
assignment students should complete for homework and turn in for later feedback.

Instead it should be conducted in the classroom with immediate instructive feedback.

For example, Marcus writes, “The man slowly plodded down the alley” on the board and has the students copy the sentence. He then directs them to use the skill’s steps to evaluate the sentence’s modifiers. Marcus then asks a student to demonstrate the skill by “thinking aloud,” speaking throughout the process, “I see the word slowly in the sentence. It modifies the word plodded. Plodded means to walk slowly. Since slowly repeats the meaning, I will eliminate it.” The teacher repeats this activity with additional sentences to help students develop their capability. Each time they proceed step-by-step through the skill’s steps.

Skills in other disciplines have similar COmprehension strands. For example, a math teacher teaching students to plot ordered pairs on a graph would explain and demonstrate the skill’s steps:

1. Identify the $x$-coordinate, the first number in the ordered pair, and find that position on the $x$-axis.

2. Identify the $y$-coordinate, the second number in the ordered pair, and find that position on the $y$-axis.

3. Find the spot where the $x$-axis and $y$-axis positions intersect.

4. Mark that point.
The students would then restate and sequence the steps, possibly by creating a flow chart. The teacher then guides the students in making connections between the skill’s steps and examples of the pattern, possibly relating it to identifying intersections on a map, which would have been explored in the EXperience strand. Students would then practice plotting points as the teacher stays nearby to offer direction as needed.

The COmprehension strand equips students with the knowledge of how to use the skill (Figure 3.9). Learning proceeds from the teacher’s explanations and demonstrations to the students’ initial attempts at evaluating modifiers. This equips students to employ their newfound knowledge during the APplication Strand.

<table>
<thead>
<tr>
<th>Architecture of Learning™: SKILL BLUEPRINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill: Revising Modifiers</td>
</tr>
<tr>
<td></td>
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<tr>
<td><strong>CORE PROCESSES</strong></td>
</tr>
<tr>
<td>experience</td>
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<tr>
<td>FOCUS Experience</td>
</tr>
</tbody>
</table>

| FOCUS Comprehension | Revising Writing: Modifiers | Sequencing the Steps | Modifier Revisions and Experience | Initial Practice, Instructive Feedback |

*Figure 3.9 Unit COmprehension Strand*

**APplication Strand**

The APplication strand repeats several times to provide the practice that develops skill proficiency. The strand’s cell sequence prompts deliberate thinking prior to applying the skill. As the practice continues, the center cells (AP-co and AP-el) merge and shorten, indicating increased efficiency with the skill (Figure 3.10).
<table>
<thead>
<tr>
<th>FOCUS</th>
<th>APplication</th>
<th>AP-ex</th>
<th>AP-co</th>
<th>AP-el</th>
<th>AP-ap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present a scenario or problem</td>
<td>Engage students in identifying the relevant contextual components (e.g., pattern illustrated by the scenario) and/or skill-related components (e.g., steps of the skill process)</td>
<td>Provide opportunity to compare anticipated steps with the pattern</td>
<td>Provide opportunity to use the skill to address the scenario</td>
<td>* * *</td>
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<tr>
<td></td>
<td>* * * * * *</td>
<td>* * * * * *</td>
<td>* * * * * *</td>
<td>* * * * * *</td>
<td>This initiates pre-application thinking</td>
</tr>
</tbody>
</table>

**Figure 3.10 APplication Strand General Descriptors**

In AP-ex, a teacher presents his students with resources and reasons to practice the skill. For example, Marcus gives the students copies of an essay featuring several modifiers. Reading the essay initiates the strand’s remaining activities.

Progressing to AP-co, students review the skill’s steps and begin *thinking through* how to apply the skill. For example, students reread the distributed essay sentence by sentence. With each sentence, they *find* any modifiers, identify and *consider* each modifier’s target and the modifier’s role in relation to it, and *choose* to keep or eliminate the modifier. Stopping to think about each decision enables higher-quality responses. *The student does not actually make the revision to the essay yet, but thinks through what*
changes may be beneficial. Marcus may initially guide the students through this thinking, but such direction lessens as students continue to practice.

The AP-el activity provides an evaluative pause between deliberately thinking through the skill and actually using it. For example, Marcus directs the students to ask themselves, “Does the way I am considering this modifier illustrate the pattern: Find, consider, and choose?” If not (e.g., the student may have identified a modifier and changed it without identifying its targeted word or considering its relationship to the targeted word), the student rethinks the decision by applying the skill’s three steps (AP-co). If he correctly used the skill—i.e., if the thinking mirrors the pattern of find, consider, and choose—he is ready to take action.

In the APplication strand’s final cell, AP-ap, students act upon their decisions. In this example, Marcus’s pupils actually revise a sentence’s modifiers or leave the text as it is.

Similarly, with the math unit, students would practice plotting ordered pairs on a graph. The teacher supplies the pairs to be plotted, the students work through the steps of the skill, compare their thinking with the pattern (perhaps “Interesting points form where things intersect.” Does my potential point show things intersecting?), and then plot the ordered pair. The teacher would still be available to offer help, but the students would work with increasing independence and efficiency.
The APplication strand flows as a series of related activities (Figure 3.11). Unlike the EXperience and COmprehension strands, the APplication strand repeats multiple times. Repeating the strand provides the practice necessary to transform knowledge to utility.

**Figure 3.11 APplication Strand for Revising Modifiers**
**INtention Strand**

The INtention strand promotes transfer of a learned skill by widening the contexts in which students experience the skill’s application (Figure 3.12).

**Figure 3.12 INtention Strand General Descriptors**

To begin the INtention strand (IN-ex), Marcus has the students generate a short story or a written report. Students then identify modifiers within the written text and deliberate over whether or not to make a change (IN-co), compare their thinking with the established pattern to be sure they’re applying the skill correctly (IN-el), and take appropriate action, revising the text or leaving it as is (IN-ap). Repeating these steps for each modifier produces completed revisions, enabling students to develop final drafts of their writing. The INtention strand mirrors the APplication strand, but it widens the context for using the skill. This process, creating an original work and revising it,
simulates the “real world” practice of writers. It encourages students to begin integrating the skill into their interactions with real-world scenarios.

In the unit on plotting points on a graph, the teacher engages students in thinking similar to the Application strand, but with actual data. For example, the teacher may have the students plot their scores on video games (played at home) over several days, or the class may plot the number of books they read each week, or plot scores on various challenges, such as word puzzles, logic puzzles, and number puzzles. In addition to actually plotting data they generate, the students see how plotted data provides opportunities for interesting comparisons. Did my video game performance improve over time? Did I score better on word puzzles, logic puzzles, or number puzzles? The Intention strand’s emphasis on using the skill in different contexts deepens and extends learning as students discover new uses for the skill and the results from applying it.

Applying a skill in isolation (as in the Application strand) differs from applying a skill within a context (as in the Intention strand). Applying the skill in a new context typically requires more thinking than using it during classroom practice. An analogy can be drawn to wannabe drivers. They usually earn a learner’s permit before being allowed behind the wheel of a car, and initial driving in a confined context (e.g., an empty parking lot) often follows. To earn the learner’s permit, the wannabe driver must possess knowledge of driving and the laws that govern it. Driving in a confined context
prompts practice of that knowledge and develops driving skills. However, as anyone who has learned to drive has experienced, the knowledge required to earn the driver’s permit and the initial use of driving skills in an empty parking lot (practice in isolation) differs significantly from safely driving a car in varying traffic and road conditions (application in a widened context). Continued coaching from an experienced driver increases achievement and accelerates learning as the fledgling driver moves from the parking lot to the interstate. This difference—practicing a skill in a confined context vs. applying it in widened contexts—distinguishes the Application and Intention strands, and learning continues to deepen as teachers provide instructive feedback throughout both strands.

The Intention strand also deepens learning by engaging students in recall of previous learning. Researchers Karpicke and Roediger claim that additional studying once material is learned produces no effect on the recall required for transfer, but repeatedly recalling the material increases the likelihood of the later recall that enables transfer. “If a person wants to remember an event or some information over the long term,” suggests Roediger, “it must be actively engaged, and retrieving information from memory serves that purpose well...Repeated retrieval over time is critical to effective, long-term retention.”² By presenting scenarios that require using previously learned skills throughout the school year, teachers engage students in “repeated retrieval.” This
increases the likelihood of their long-term retention, which is critical to the transfer of learning from the classroom to the world at large.

For example, Marcus could plan to repeat the INtention strand for every writing assignment throughout the rest of the school year. Students would engage in revising writing by eliminating nonessential modifiers multiple times, and each recall of the skill would promote future recall and increase the likelihood of future use.

Teaching, like Marcus’s, that carries students from referential experience to integrated learning requires intentionally designed instruction. The completed Architecture of Learning™ Skill Blueprint for revising modifiers illustrates such instruction (Figure 3.13). It recognizes what students will do with their learning (use the skill to improve writing quality), connects new material to prior experiences via pattern-based (find, consider, choose) reference points, and mirrors the brain’s means of learning through the focus strands and their interactions with the core processes (Figure 3.14).
### Architecture of Learning™: SKILL BLUEPRINT

**Skill: Revising Modifiers**

#### CORE PROCESSES

<table>
<thead>
<tr>
<th>Process</th>
<th>Experience</th>
<th>Comprehension</th>
<th>Elaboration</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXperience</strong></td>
<td>Plane Construction</td>
<td>Guided Review</td>
<td>The Plane Pattern</td>
<td>Pattern Examples from Experience</td>
</tr>
<tr>
<td><strong>COmprehension</strong></td>
<td>Revising Writing: Modifiers</td>
<td>Sequencing the Steps</td>
<td>Modifier Revisions and Experience</td>
<td>Initial Practice, Instructive Feedback</td>
</tr>
<tr>
<td><strong>APplication</strong></td>
<td>An Essay to Revise</td>
<td>Working the Skill</td>
<td>Pattern Pause</td>
<td>Revising</td>
</tr>
<tr>
<td><strong>INtention</strong></td>
<td>Student-Generated New Material</td>
<td>Working the Skill</td>
<td>Pattern Pause</td>
<td>Revising &amp; Final Drafts</td>
</tr>
</tbody>
</table>

*Figure 3.13 Unit INtention Strand*
### Architecture of Learning™: SKILL BLUEPRINT

#### Experience

<table>
<thead>
<tr>
<th>EX-ex</th>
<th>EX-co</th>
<th>EX-el</th>
<th>EX-ap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide an experience that illustrates a pattern</td>
<td>Engage students in identifying and sorting the experience's defining attributes</td>
<td>Guide pattern recognition and statement development</td>
<td>Enable pattern identification within personal experiences</td>
</tr>
<tr>
<td>This establishes a reference point for constructing understanding</td>
<td>This establishes the critical components of the emerging pattern</td>
<td>This enables a connection between the referential experience and forthcoming learning</td>
<td>This establishes personal connections to the pattern and forthcoming learning</td>
</tr>
</tbody>
</table>

#### Comprehension

<table>
<thead>
<tr>
<th>CO-ex</th>
<th>CO-co</th>
<th>CO-el</th>
<th>CO-ap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present new content and/or skill processes to be mastered</td>
<td>Engage students in identifying and organizing the new material</td>
<td>Direct students to overlay new material, reference point (EX-ex), and/or personal reference points (EX-ap)</td>
<td>Facilitate guided and supported practice or summarization of the new material</td>
</tr>
<tr>
<td>This provides the new material to be learned</td>
<td>This establishes the new knowledge students must acquire</td>
<td>This initiates merging of the new and known to construct understanding</td>
<td>This reveals and helps establish student knowledge of the new material</td>
</tr>
</tbody>
</table>

#### Application

<table>
<thead>
<tr>
<th>AP-ex</th>
<th>AP-co</th>
<th>AP-el</th>
<th>AP-ap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present a scenario or problem</td>
<td>Engage students in identifying contextual components (e.g., pattern illustrated by the scenario) and/or skill-related components (e.g., steps of the skill process)</td>
<td>Provide opportunity to compare anticipated steps with the pattern</td>
<td>Provide opportunity to use the skill to address the scenario</td>
</tr>
<tr>
<td>This initiates practice</td>
<td>This initiates pre-application thinking</td>
<td>This confirms or redirects the student's intended use of the skill</td>
<td>This initiates skill utilization to produce a result or solution</td>
</tr>
</tbody>
</table>

#### Intention

<table>
<thead>
<tr>
<th>IN-ex</th>
<th>IN-co</th>
<th>IN-el</th>
<th>IN-ap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present a scenario or problem from a wider context</td>
<td>Provide a way to identify and organize the IN-ex scenario</td>
<td>Provide opportunity to identity commonalities of new scenario and content or skill</td>
<td>Provide opportunity to make a prediction/use the skill to address scenario</td>
</tr>
<tr>
<td>This initiates recall and transfer of mastered material</td>
<td>This exposes the relevant scenario components and their emerging pattern(s)</td>
<td>This promotes the use of learned concepts and skills in addressing the scenario</td>
<td>This represents transfer, true integration of the new learning</td>
</tr>
</tbody>
</table>

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### Architecture of Learning™: SKILL BLUEPRINT

**Skill: Revising Modifiers**

<table>
<thead>
<tr>
<th>experience</th>
<th>comprehension</th>
<th>elaboration</th>
<th>application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane Construction</td>
<td>Guided Review</td>
<td>The Plane Pattern</td>
<td>Pattern Examples from Experience</td>
</tr>
<tr>
<td>Revising Writing: Modifiers</td>
<td>Sequencing the Steps</td>
<td>Modifier Revisions and Experience</td>
<td>Initial Practice, Instructive Feedback</td>
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<tr>
<td>An Essay to Revise</td>
<td>Working the Skill</td>
<td>Pattern Pause</td>
<td>Revising</td>
</tr>
<tr>
<td>Student-Generated New Material</td>
<td>Working the Skill</td>
<td>Pattern Pause</td>
<td>Revising &amp; Final Drafts</td>
</tr>
</tbody>
</table>

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**Figure 3.14 Skill Blueprint “Before and After”**

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*Washburn/THE ARCHITECTURE OF LEARNING™: DESIGNING INSTRUCTION FOR THE LEARNING BRAIN*
Blueprint “Rhythm” and Flow

The Blueprint strands reveal a simple consistency (Figure 3.15). Within every strand, core cognitive processes direct how the instruction will progress, establishing a natural rhythm: data is introduced (ex), identified and reorganized (co), so emerging patterns can be recognized and compared with previous experience (el), resulting in new understanding used to demonstrate a level of mastery (ap). The underlying instructional rhythm—input→processing→output—directs the flow of every strand.

<table>
<thead>
<tr>
<th>CORE PROCESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>experience</td>
</tr>
<tr>
<td>Sensory data is introduced...</td>
</tr>
</tbody>
</table>

As the rhythm repeats through the strands, teachers and students flow seamlessly from new exposure to the transfer of new learning within expanding contexts (Figure 3.16).
Students construct airplanes. Teacher guides review and sorting of the experience’s details and the identifying of the pattern: find, consider, choose. The students identify personal examples that illustrate the pattern.

Teacher presents and demonstrates the action sequence for revising modifiers. Students review and sort the action sequence steps. Teacher guides student thinking about the new skill and its connection to the pattern and its referential illustrations. Teacher guides initial practice of the new skill.

Students read text provided for skill practice. Students use the skill to consider modifier revisions, check consistency of their skill use and its underlying pattern, then make the desired revision. Students repeat this process until all practice is completed.

Students generate text passages, such as a report or short story. Students use the skill to consider modifier revisions, check consistency of their skill use and its underlying pattern, then make the desired revision. Students repeat this process until all revisions are completed. Teacher repeats the strand multiple times throughout the school year.

### Questions

1. What is a skill? List three examples from your experience as a teacher or student.

2. What role do patterns play in skill learning? What is the source for identifying skill patterns?

3. What are the strands of the Architecture of Learning™ Skill Blueprint? Why are these the strands?

4. How are cells formed on the Blueprints?

5. Review Figure 3.15 and explain the basic consistency found in each strand.

6. Review Marcus’s unit. What would you expect students to master as a result of his instruction?
Notes


Imagine yourself as a student of abstract art history. Your teacher walks into class with three tubes of paint. She holds each tube up, one at a time, for the class to see.

“This particular shade of yellow is the yellow Jackson Pollack used in his painting *Yellow, Gray, and Black,*” she explains. She then holds up the gray and explains it is the gray used in the same painting, as is the tube of black paint. She discusses the critical attributes of each shade—“The yellow is really more of a mustard with strong hints of orange.” You find this detailed information fascinating, even though you’ve never seen the painting using these colors. The teacher then announces, “To be sure you’ve learned today’s lesson well enough to think critically, we are going to have a test. You will each receive a blank canvas and a pallet with large dollops of this yellow, gray, and black paint. After receiving your materials, recreate Jackson Pollack’s painting as closely as possible.” Hands, including yours, immediately go up around the room. The teacher replies, “I know that I have not shown you this painting. Remember, I am testing to see how well you can think about the material.”

Seem unfair? The teacher explained the isolated facts thoroughly. Why do you feel cheated? If you just “put on your thinking cap,” could you be successful? Would your results be an accurate and fair representation of your abilities and understanding?
Haphazard assessment can give a flawed impression of a student’s true achievement. Educator and parent Ken O’Connor relates an experience that illustrates this method and the justification often used to support it:

Throughout his high school career, my son had great difficulty completing tests within the set time limit, often leaving unfinished work that lowered his grade. I will never forget one year when his English teacher came up to me in the local supermarket and said, “You know your son’s grades don’t accurately reflect what he knows and understands in English.” My response was that if she was confident in this judgment, she should make the appropriate changes in his grade to reflect her belief. She replied, however, that she could not do this because all his scores had to be averaged to determine the report card grade. To me, this teacher had a misconception of what a grade represented.¹

The teacher recognized the difference between the student’s abilities and his grade but chose to record the misrepresentative grade anyway. Such misalignment diminishes the integrity of both the teacher and the school. So we have to ask ourselves: What causes this disparity? Let’s observe three teachers as they complete an end-of-marking-period ritual.

While preparing report cards, Miss Snyder, Mr. Stilman, and Mrs. Sheffield discover a disturbing trend. Miss Snyder notices that Jimmy, who reads well below grade level, earned enough points from assignments and assessments to have a C in
reading—a passing grade that inaccurately represents his progress. Mr. Stilman notices the same problem. Through points given for completed homework and corrected work, Joanie earned a passing grade in math. Mr. Stilman knows she will experience frustration and likely failure next year because she hasn’t mastered basic concepts, despite what her grade appears to indicate. Mrs. Sheffield sees a different problem with Justin’s language grade. The D that indicates he is failing results from his poor sentence-diagramming skills. However, Justin’s writing capacities indicate a deep understanding of grammar and a level of communication that exceeds grade-level expectations. Oh well, each teacher concludes, how can you give a grade other than what the point values indicate? The three teachers knowingly communicate grades that are false representations of each student’s true achievement. They create a disparity between a student’s abilities and what they communicate about those abilities.

In Architecture of Learning™, the learning process guides the teaching process, which leads to the assessment process. Such coherence between teaching, learning, and assessment is essential for producing learning that is “integrative so that it lasts.” Assessing a subject in ways that differ from how we taught it places our integrity as professionals in question.

**Assessment for Learning: Instructive Feedback**

The test given at the end of a unit should represent a miniscule percentage of actual classroom assessment. Most assessment should be *formative* as opposed to
Formative assessment forms the student as the teacher monitors progress and provides feedback. A teacher’s assessment activities while a student is learning can significantly influence her achievement.

Researchers Paul Black and Dylan Wiliam describe formative assessment as any activity that provides information about student learning and enables teachers to adapt teaching to meet student needs. Such activity resonates with the original meaning of assessment. The word assess has its origins in the Latin term assidere, meaning “sit by.” Formative assessment is a vital teacher-student dialogue, a “sitting by,” that improves teaching and increases learning. Educators and authors Grant Wiggins and Jay McTighe remind us that such feedback is essential: “Learning requires regular, timely, and user-friendly feedback to understand goals, produce quality work, and meet high standards.” Assessment experts Leahy, Lyon, and Wiliam describe this as “assessment for learning rather than assessment of learning,” and Grant Wiggins argues for more of it:

Here's a radical idea: We need more assessment, not less.

Seem crazy? Substitute feedback for assessment, and you'll better understand what I mean. The point of assessment in education is to advance learning, not to merely audit absorption of facts. That's true whether we're talking about that fourth-period pop quiz, the school play, or the state test. No one ever mastered a
complicated idea or skill the first—or fifth—time. To reach any genuine standard, we need lots of trials, errors, and adjustments based on feedback.

Think of assessment, then, as information for improving.⁶

Educators and authors Susan M. Butler and Nancy D. McMunn also describe assessment’s role as a means of increasing learning:

Classroom assessment is of vital importance to student learning. Research demonstrates that student achievement is increased (particularly for low student achievers) by the use of classroom assessment when such assessment features good feedback to students about their performance, sets clear standards for learning, is ongoing so it can be used to monitor student growth and progress, and is used to modify instruction to meet the needs of the student...Such classroom assessment promotes assessment for learning rather than assessment of learning.⁷

Teachers increase learning through instructive feedback, a major component of formative assessment. Instructive feedback is “teacher-student interaction in which the comparison of student work with defined levels of proficiency provides the student with direction for future work and increased proficiency.”⁸ According to researcher John Hattie, it is “the most powerful single modification that enhances achievement,”⁹ and Paul Black and Dylan Wiliam call instructive feedback “the heart of effective teaching.”¹⁰
Instructive feedback follows a four-step cycle. First, a student shows his level of understanding while practicing a skill or processing new content. For example, in learning to handwrite the letter \( q \), students generally practice forming the letter. In a more advanced class, learning the cause-effect sequence of the water cycle, students may develop detailed diagrams. Both their practice of the skill and their grasp of the topic can produce a basis for instructive feedback.

Second, the teacher compares the student’s work with defined standards. The teacher identifies:

1. Elements in the student’s work that conform to the standards
2. The overall level of proficiency the student’s work represents
3. Elements the student does and does not appear to understand
4. Ways the student can achieve greater proficiency

Though generally done quickly, the teacher’s review yields details that shape the final steps of the cycle.

During the third step’s pivotal dialogue, the teacher begins by identifying what the student has done well and appears to understand. The teacher then asks her to comment on the work completed thus far. This gives the student an opportunity to correct the teacher’s perceptions, offer additional evidence of understanding, or ask important questions about the material. The teacher follows with questions of clarification, if necessary, and encourages the student to respond. This dialogue, a
balance of encouragement and exhortation, creates an environment that enhances learning.

In the cycle’s final step, the teacher and student develop an improvement plan. The teacher offers specific suggestions of what the student can do to achieve more. In forming the plan, the teacher refers to established standards (often detailed on a rubric) and suggests specific, concrete actions the student can take. As the student acts on the plan, new evidence of understanding is produced, returning the four-step process to its start.

My wife’s interactions with piano students illustrate the instructive feedback cycle. A student plays a previously assigned and practiced piece (step 1). My wife then comments on the performance, saying things like, “You played the introduction well. The timing was correct and you played it expressively” (step 2). She then asks the student what he thought about the piece and listens carefully. In response, she interacts accordingly and then offers a suggestion: “Let’s look at this middle section and tap the rhythm together” (step 3). Together, they discuss how to practice the piece, especially the sections that need more work (step 4). The next week, if the student has practiced as directed, the performance improves.

Professor of biology James E. Zull suggests that providing teacher feedback triggers the learner’s sense of progress. This sensation ignites activity in the brain’s basal structures, neural regions associated with pleasure and reward. Such “active
learning,” claims Zull, makes learning “pleasurable and effective for developing concepts and applications.”

Research confirms that increasing instructive feedback increases learning. Robert J. Marzano found that students who had teachers that consistently provided timely and specific feedback scored anywhere from 21 to 41 percentage points higher on standardized tests than students who had teachers that failed to provide such feedback. Neurologist and classroom teacher Judy Willis offers one reason for this dramatic impact: “One of the most successful strategies for engaging students’ brains in their lessons comes from personal connection and accountability.” Through frequent instructive feedback, teachers connect with individual students, hold them accountable, provide an opportunity for a student’s questions, and optimize learning and achievement.

**Based on Learning, Revealed by Teaching**

Instructive feedback helps align learning, teaching, and assessment, but how do we fairly assess student achievement? What relationship should testing have to instruction? Architecture of Learning™ Blueprints aid teachers in activating learning processes, but tests frequently require more knowledge and skill than teachers have taught. A teacher, for example, may present isolated factual content during instruction and then ask a “critical thinking” test question that requires a synthesis and evaluation of the material. When asked about this inconsistency, teachers often respond that it is a
way to tell who has “really learned” the material. But this practice and the justification offered for it reveal a lack of understanding about how learning develops. If an assessment requires learning that the teacher failed to foster, it asks students, in effect, to reproduce a painting after only seeing separate tubes of paint. We certainly want students to build their own understanding of instructional material, but our teaching, not our assessment, needs to enable this.

The Architecture of Learning™ Blueprints help teachers develop assessments based on learning and revealed through teaching. The Blueprints create “critical intersections” (Figure 6.1). These points, where a focus process (strand) meets itself in the core processes (column), can guide a teacher’s choice of testing material and how the test asks a student for the material. By engaging in formative assessment and developing summative assessments based on a unit’s critical intersections, a teacher imbues educational practice with integrity.

<table>
<thead>
<tr>
<th>process</th>
<th>experience</th>
<th>comprehension</th>
<th>elaboration</th>
<th>application</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXperience</td>
<td>Critical Intersection: Reference Point</td>
<td>EX-co</td>
<td>EX-el</td>
<td>EX-ap</td>
</tr>
<tr>
<td>Comprehension</td>
<td>CO-ex</td>
<td>Critical Intersection: Knowledge</td>
<td>CO-el</td>
<td>CO-ap</td>
</tr>
<tr>
<td>Elaboration</td>
<td>EL-ex</td>
<td>EL-co</td>
<td>Critical Intersection: Understanding</td>
<td>EL-ap</td>
</tr>
<tr>
<td>Application</td>
<td>AP-ex</td>
<td>AP-co</td>
<td>AP-el</td>
<td>Critical Intersection: Utilization</td>
</tr>
<tr>
<td>Intention</td>
<td>IN-ex</td>
<td>IN-co</td>
<td>IN-el</td>
<td>Critical Intersection: Integration</td>
</tr>
</tbody>
</table>

Figure 6.1: The Architecture of Learning™ “Critical Intersections”
EX-ex: The Reference Point

A Blueprint’s first cell forms its first critical intersection: EX-ex. While this cell does not produce material for assessment, it influences the other critical intersections. The EX-ex activity features an experience that illustrates a pattern. That experience becomes the “reference point” for the learning—the understood element to which the mind returns again and again as it constructs understanding of new material.

CO-co: The Knowledge Component

The CO-co intersection represents the unit’s knowledge component. It features the unit’s factual material and answers the question, “Does the student know the essential details and how to effectively organize them?” In terms of learning a skill, the knowledge component includes the skill’s individual steps and their correct sequence. For example, if a student is trying to identify the main idea of a text passage, the knowledge component includes knowing a definition of main idea and the three steps that guide main idea identification. It is not actually identifying a main idea from a passage. In units featuring content, the critical details of the material compose the knowledge component. Such components for a unit on Romanticism include the definition of Romanticism and a list of major Romantic authors. In combination units, the knowledge component includes knowing the pattern and the associated skill’s sequence of steps. For example, the knowledge components of an early elementary unit on solving word problems requiring addition include stating or describing the pattern that suggests addition as a solution and stating the steps for finding a solution by using
addition. In short, if it can be recited and/or organized, it is probably a knowledge component.

This suggests two important implications, one for designing instruction and one for developing assessments. First, the CO-co activity should clearly engage the students in restating and reorganizing the knowledge components. If the activity fails to emphasize an important element of the unit’s knowledge component, the activity needs to be redesigned or expanded. By reviewing the CO-co intersection this way, a teacher can self-coach and improve instructional design. (Think of this as self-provided instructive feedback!) When I review an Architecture of Learning™ Blueprint, the CO-co activity is the first element I examine. If the unit’s foundational knowledge is not represented there, it is the first thing I work with a teacher to improve.

For example, recently while working with a mid-elementary teacher on a science unit, I noticed her test included a section for cloud types and associated weather conditions. As we reviewed her unit, I noted that the students never sorted these associations themselves. We examined her CO-co cell and found other details being addressed but nothing about cloud-weather connections. The teacher told students about the associations, but the students never processed these details. We revised her CO-co activity so that the students actually processed the knowledge required to successfully complete that section of the test.
Second, the CO-co critical intersection should inform assessment. What students are asked to recall on a test and the way they are asked to reorganize the data should clearly relate to the CO-co activity. For example, on a test for identifying main ideas, I may ask the students to write a definition of *main idea* and to write, in order, the steps used to identify main idea. The assessment’s knowledge component should echo the content and form of the unit’s CO-co critical intersection. This pulls together teaching and assessing of the learner’s comprehension of the unit’s content.

When instruction and testing do not align this way, students are placed at an unfair advantage. For example, a Spanish teacher may teach individual vocabulary terms, asking students to match Spanish terms with English definitions in the CO-co stage of the unit. However, on the test, the teacher may ask the students to translate sentences in which some words appear in a different form because they are used in context. Not only do students lack the experience of interpreting sentences, they may also lack basic knowledge of words forms and the influence of context. The teacher’s testing has a tentative relationship to her teaching.

**Critical Intersection EL-el: The Understanding Component**

The EL-el intersection, which appears in the Content and Combination Blueprints, represents a unit’s *understanding component*. It comprises the unit’s interrelated ideas and their connections to students’ prior experiences. It answers the question, “Does the student demonstrate understanding through connections of new
and known concepts?” For example, within a unit on the Byzantine Empire, students may identify influencers and influences in the Byzantine era and from their personal experiences, relate the Byzantine influencers to personal influencers, and explain how the personal examples are illustrative of the Byzantine examples. A student may, for example, relate the Byzantine Church to a modern political party, explaining that both possessed significant influence over the thinking of leaders. A student’s ability to identify and explain such connections reveals an understanding of the unit’s content.

An assessment of student understanding should be a part of the assessment “package” for a unit. While it may be included in a test at the unit’s conclusion, it may also be based on student work produced prior to the final test. For example, within the Byzantine Empire unit, the teacher could expand the EL-ap activity by asking students to identify corresponding contemporary illustrations for every influencer and influenced area, individual, or group detailed in the unit’s new material and write a multi-paragraph essay explaining each illustration. Such an assignment could be completed partially in class, creating opportunities for instructive feedback, and partially for homework. The resulting evidence would reveal the student’s understanding of the unit’s critical ideas, the relationships between them, and the connections between these related ideas and experience. A rubric would then guide the teacher’s evaluation of the completed essay.
AP-ap and IN-ap: The Utilization and Integration Components

The AP-ap intersection, which appears in the Skill and Combination Blueprints, represents the unit’s utilization component. It emphasizes the sequence of steps used to accomplish a goal—i.e., the actual doing of the skill—and answers the question, “Does the student know how to achieve the desired result by applying the skill?” For example, if the skill is overhand throwing, the student’s ability to throw a ball overhand in isolation, not within a wider context such as a softball game, represents the utilization component. If the skill is multiplication of two-digit numbers by single-digit numbers, a student’s ability to calculate correct products represents the utilization component.

One additional critical intersection exists in each Blueprint. The IN-ap cell represents the ability to use new knowledge within a new context, the unit’s integration component. It answers one of three questions:

1. When placed in a relevant context, does the student apply the skill accurately and with adequate efficiency?

2. Does the student use conceptual understanding to analyze current conditions and make predictions or generate solutions?

3. Does the student use conceptual understanding to analyze current conditions and apply the associated skill for a satisfactory result?

For skills, the integration component refers to a student’s ability to replicate the process within a context—to transfer the learning. For example, with identifying main
idea, integration would be demonstrated by his ability to independently identify the main idea of a new nonfiction text passage.

With content, integration is illustrated by a student’s ability to apply her understanding to new contexts. “The learner begins to integrate, to continually make connections and create new wholes out of multiple parts: his or her knowledge and ability, individual abilities needed in a given situation, and abilities and the situation or context.”14 By engaging in activities requiring integration, a learner “extends, deepens, and secures” understanding and capability.

For example, the unit on Romanticism required students to consider how a pull in one direction can cause a push (or reaction) in the opposite direction. A teacher may read a news article detailing a current movement in cultural values, such as increased movement to technology-based, less expensive customer service, and ask the students to discuss its content. The teacher may then ask the students to consider content understandings they have constructed, apply these to the scenario detailed in the article, and offer some insights, such as predictions, advice, or potential solutions to problems. (You should note that such thinking will need to be modeled and practiced with instructive feedback several times before you can expect students to extrapolate on their own.) Some insights may be discussed, and the teacher may then ask the students to compose a response to the article, such as a letter to the editor, using their insights on Romanticism to explore and explain reactions to the contemporary movement.
Such an activity would likely take place sometime after the unit has been completed, and a rubric would guide evaluation. However, since the INtention Strand is most effective when repeated multiple times throughout the year, such a formal approach is not always required or justified. In fact, most INtention Strands are best approached informally, allowing students to explore the relationship of their new understanding to contemporary circumstances. The teacher who frequently uses such an informal approach in short interactions (only occasionally requiring a more detailed, formal response for evaluation) uses the proper balance.

Within a Combination Blueprint, the IN-ap cell merges both the new concept and associated skill within a widened context. For example, within a math unit on division, a teacher may arrange a scenario in which students experience the need to separate items or people into equally sized groups. The students analyze the context to identify this pattern and apply the associated skill (division).

Being able to use new content and skills represents authentic learning. Educator and assessment expert Eeva Reeder claims, “The degree to which students grasp a concept can be reliably inferred only when they can somehow apply the concept in an authentic context. In other words, students cannot reasonably claim to understand what they cannot demonstrate.” Integration is the evidence of authentic learning.
Assessment of Learning: Summative Assessment

Thorough assessment reveals student knowledge (represented by the CO-co cell), understanding (represented by the EL-el cell), and/or utilization (represented by the AP-ap cell), and integration (represented by the IN-ap cell) of new material. A teacher can design connections between the content and method of assessment and the content and method of instruction by using the unit’s critical intersections as a guide.

Knowledge components are clearly defined and can often be assessed via “traditional” methods (e.g., multiple choice, matching, fill in the blank). However, alignment between the CO-co cell and the testing methods should be obvious. For example, if in class students identify the major events of the antebellum period prior to the Civil War and arrange those events in sequential order, a multiple-choice test is unlikely to mirror the form even though it may cover the same details. A stronger alignment would be created if students were given a list of events and asked to sequence them in a timeline.

Assessing the understanding (EL-el), utilization (AP-ap), and integration (IN-ap) components requires additional thought and effort. While each of these elements possesses levels of proficiency, determining a student’s achievement is nearly impossible with “traditional” test structures. Labeling a statement as true or false, selecting an option from a choice of four, or matching two corresponding ideas (e.g., term and definition) reveals little, if any, depth of understanding, ability in utilization, or transfer of learning (integration).
Rubrics enable assessment beyond the knowledge level by providing “an outline of the criteria” used to determine student achievement. A descriptive rubric is one practical and helpful form. It details the evidence associated with various achievement levels. The specific labels assigned to these levels vary, but here are four terms that would work: exemplary, proficient, adequate, and not yet.

For instance, the teacher who required the students to pair influences from their own experiences with influences of the Byzantine era could assess the resulting connections in this fashion (see Figure 6.2).

<table>
<thead>
<tr>
<th>Connections &amp; Explanations</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Adequate</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student work features connections (with explanations) between Byzantine and contemporary influences, revealing relationships between both broad and specific ideas (e.g., connecting Justinian with the authors of the Constitution, explaining that both created codes that influenced later systems of governance, and both created codes that designated legislation as the source of laws)</td>
<td>Student work features connections (with explanations) between Byzantine and contemporary influences, revealing recognition of links based on relationships, such as cause and effect or prototype and later forms (e.g., connecting Justinian with the Pilgrims, explaining that both created “codes” that became the basis for later documents establishing legal systems)</td>
<td>Student work features connections (with explanations) between Byzantine and contemporary influences, revealing recognition of links across broad areas (e.g., connecting Justinian’s contribution of codifying law with a current judge because both influence issues of law)</td>
<td>Any responses not meeting the Adequate descriptors</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.2: Sample Rubric

Adequate work might be described as identifying connections between the ideas, revealing recognition of links across broad areas (e.g., a student connects Justinian’s contribution of codifying law with a judge because both influence issues of law). In contrast, proficient work might be described as identifying connections between the
ideas, recognizing links based on relationships, such as cause-effect or prototype-later forms (e.g., a student connects Justinian with the Pilgrims, explaining that both created “codes” that formed foundations for future legal systems). Exemplary work might be described as identifying multiple connections and explanations that reveal relationships between both broad and specific ideas (e.g., a student connects Justinian with the authors of the Constitution, explaining that both created codes that influenced later systems of governance, and both created codes that designated legislation as the source of laws). Adequate means the student can articulate connections that reveal a basic understanding. Proficient means the student can articulate more than one-to-one connections, explaining related ideas and their relationships. Exemplary describes the student that can articulate both broad connections and significant, detail-based connections.

The question naturally arises: Isn’t this a subjective assessment? The answer is both yes and no. The teacher does make a judgment regarding the level of achievement, but she bases this judgment on predetermined standards. The standards reveal consistency between expectations (i.e., objectives) and achievement. Because rubrics set out predetermined descriptors of established standards, they can help ensure evaluative integrity. Assessing more than factual recall requires such an approach.
Assessment for and of Learning: Rubrics & Instructive Feedback

However, the most significant contribution rubrics make to learning is their role in instructive feedback. This cycle of feedback revolves around established achievement standards (see Figure 6.3). Prior to assigning a task that will produce evidence for review, the teacher must consider how various levels of achievement will be gauged. What are the defining characteristics of achievement that is adequate? proficient? exemplary? When students have this information before them (e.g., copies of the rubric distributed in the CO-ex cell), the rubric serves as a guide for the desired depth of learning, and it provides a tool for instructive feedback. The teacher can review student work and plan for improvement by referencing the rubric. For example, a teacher may note a student’s connections made during the EL-el activity indicate one-to-one, surface-level connections that, though not incorrect, reveal only a beginning understanding. The teacher may commend the student for recognizing these connections and then suggest the student consider broader areas of connection. The rubric provides a “place to go” in giving feedback and establishing the “next step” in the student’s efforts.
Tests, papers, and projects, for which grades are assigned, should be structured to assess student knowledge, understanding, and/or utilization, and possibly integration. Again, the critical intersections of the unit’s Blueprint provide guidance for form and content. The knowledge component, as indicated previously, can be addressed via “traditional” testing methods. All the other levels may or may not require rubric-based assessment, depending on the new subject matter’s structure.

For example, a unit on long division designed on a Combination Blueprint possesses all the critical intersections. The knowledge component may be addressed by asking the students to state or identify the pattern that indicates the need for division and to identify the steps used in calculating a quotient. The understanding component may ask the students to identify an illustration of a pattern and explain how it exemplifies separating a larger group into equally sized smaller groups. The utilization
component may be assessed simply through a series of long division equations for
which students calculate quotients, and a series of word problems for which students
identify those requiring long division and calculate their quotients. (In this case, a rubric
would not be needed to assess utilization.) The integration component, if addressed
during instruction, may ask the students to identify and explain a realistic situation,
based on actual or imagined experience, to which division could be applied, state the
equation representing the situation, and find its quotient (Figure 6.4)
KNOWLEDGE
Examine the following word problem:

Jack has a jar with 96 pieces of candy inside. He wants to share the candy with his basketball team. All together, there are 8 people on his team. How many pieces of candy should Jack give each person?

Using the space below, explain how you know to use division in answering the question. What pattern does the word problem present? (4 points)

Referring to the same word problem, write the correct order of operations for solving the problem (4 points).

UNDERSTANDING
In the space below, draw a picture that shows the pattern of division. If necessary, write an explanation of your picture. Use the rubric to guide your response. (This is the same rubric we used during the unit!)

<table>
<thead>
<tr>
<th>Division Illustration</th>
<th>Exemplary 10 points</th>
<th>Proficient 7 points</th>
<th>Adequate 4 points</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student's illustration includes a realistic context in which the use of division is sensible</td>
<td>All Adequate descriptors, plus...</td>
<td>Student's illustration accurately depicts the pattern of division</td>
<td>Any responses not meeting the Adequate descriptors</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.4: Sample Assessment with Knowledge, Understanding, Utilization, and Integration Components
UTILIZATION
Solve the following division equations (1 point each; 10 points).

\[
\begin{align*}
32 \div 8 &= \quad 49 \div 7 &= \quad 83 \div 9 &= \quad 51 \div 6 &= \quad 13 \div 3 = \\
26 \div 2 &= \quad 79 \div 8 &= \quad 44 \div 4 &= \quad 38 \div 7 &= \quad 67 \div 5 = \\
\end{align*}
\]

Solve the following story problems that require division. Do not solve any story problems that do not require division (1 point each; 5 points).

Sue has 14 balloons to give 7 children. How many balloons should Sue give each child?

Jack has $2.00. Fred has $1.50. How much money do Fred and Sam have all together?

Grant had 63 cookies that he gave 21 of his classmates. How many cookies did each classmate get?

Zane has 5 bags. There are 4 baseball cards in each bag. How many baseball cards does Zane have?

I want to put the same number of jelly beans in each bag. I have 48 jelly beans and 4 bags. How many jelly beans should I put into each bag?

INTEGRATION
Write about a real-life situation in which you could use division and write the equation that would provide the correct quotient. (You may write your situation into a word problem.) Then use division to find the quotient and explain how it solves or addresses the situation. Use the rubric to guide your response. (This is the same rubric we used during the unit!)

<table>
<thead>
<tr>
<th>Exemplary 7 points</th>
<th>Proficient 5 points</th>
<th>Adequate 3 points</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division Situation</td>
<td>• All Proficient descriptors, plus...</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Student explains how using division successfully addresses the situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All Adequate descriptors, plus...</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Student solves the associated equation and labels the quotient</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Student presents a situation in which division provides a solution and correctly writes the associated mathematical equation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Any responses not meeting the Adequate descriptors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Similarly, a summative assessment for a content unit can feature knowledge, understanding, and integration components (Figure 6.5). The knowledge component may, for example, ask students to recall the major characters and events of a Shakespearean play. The understanding component may require students to write an essay that explores the relationship of the unit’s referential pattern, elements of the play, and connections to personal experiences. Finally, the integration components may engage students in analysis of a contemporary situation and require a response, such as a prediction or advice, that references play elements as support. However, the teacher must ensure such assessment prompts are consistent with the teaching activities of the represented critical intersections.

Ideally, these components correspond to grading intervals. For example, the knowledge component and utilization component (combined, since both the content and skill are essential) should possess enough points to place the student in the adequate or “C-range” of a school’s grading system. The understanding component should possess enough weight (i.e., points) to move the student into the proficient or “B-range” of a school’s grading system. The integration component should possess enough weight to move the student into the exemplary or “A-range” of a school’s grading system. A student who answers all traditional questions correctly and has exemplary scores on all the rubric-based sections would earn a perfect score (e.g., 30 out of 30 possible points, or 100%).
KNOWLEDGE
Match the following characters and descriptions:

_____ 1. Weird Sisters  A. Thane of Glamis who becomes Thane of Cawdor and murderer of King Duncan

_____ 2. Banquo  B. Witness of the prophecy concerning Macbeth who is murdered for his suspicions

_____ 3. Macbeth  C. Ambitious woman who is eventually overcome by a guilty conscience

_____ 4. Malcom  D. Son of Banquo; escapes the murderers sent by Macbeth

Multiple Choice

_____ 11. Who was described as “lesser than Macbeth, and greater”? Why?
   A. Fleance because he becomes king
   B. Banquo because he becomes king
   C. Banquo because he does right but is never king
   D. Lady Macbeth because she can influence Macbeth

[section continues]
UNDERSTANDING
As we read Macbeth, we discussed and wrote about the influence one’s view of one’s self can have over one’s actions. Summarize the elements of Macbeth that address this idea and include illustrations from your own experiences. Explain logical correlations between the play, the pattern, and your own experiences. (Note: the rubric used to evaluate your response is the same rubric we used for our in-class writing during the unit.)

<table>
<thead>
<tr>
<th>Understanding Essay</th>
<th>Exemplary 20 points</th>
<th>Proficient 16 points</th>
<th>Adequate 12 points</th>
<th>Not Yet</th>
</tr>
</thead>
</table>
| • All Proficient descriptors, plus…
• Response integrates play elements and personal experiences in such a way that one mirrors the other—personal experiences are described/explained in relation to play elements, creating obvious correlations between the two | • All Adequate descriptors, plus…
• Response includes examples from personal experience that illustrate the pattern | • Response summarizes elements of the play that illustrate the pattern: Individuals tend to act in alignment with how they view themselves | • Any responses not meeting the Adequate descriptors |

INTEGRATION
Select one of the newspaper clippings from the table. Review the article carefully. Write a description of any similarities you see between the scenario explained in the clipping and the play Macbeth. Then, using your understanding of Macbeth, offer a prediction of what could occur in the scenario or offer advice to those involved in the scenario. Your response does not need to be lengthy! (Note: the rubric used to evaluate your response is the same rubric we used for our in-class writing during the unit.)

<table>
<thead>
<tr>
<th>Integration Response</th>
<th>Exemplary 10 points</th>
<th>Proficient 8 points</th>
<th>Adequate 6 points</th>
<th>Not Yet</th>
</tr>
</thead>
</table>
| • Response features significant correlations between the contemporary scenario and the play plus…
• Response includes prediction(s) or advice that are well supported/defended/justified with clearly explained references from the play | • Response features significant correlations between the contemporary scenario and the play plus…
• Response includes prediction(s) or advice that addresses the contemporary scenario and references the play | • Response describes minimal correlations between the contemporary scenario and the play | • Any responses not meeting the Adequate descriptors |

Figure 6.5: Sample Assessment with Knowledge, Understanding, and Integration Components
Note that achieving the unit’s objectives without any evidence of greater achievement earns the student a grade of adequate (i.e., a C in most grading systems). To earn higher grades, the student must produce evidence within the proficient and/or exemplary levels. This is an idea teachers often find difficult to grasp and apply. In the past, teachers may have considered achieving a unit’s objectives to represent A-level work. With such an approach, a school actually has a covert pass-fail grading system. An A is a passing mark; the student has achieved the objectives. A B or lower is a failing mark; the student did not achieve the objectives. However, teachers and schools generally consider a C to represent passing. In such a system, a student who earns a C has not mastered the objectives for the grade level and will not be prepared to achieve those of the next grade level, creating a spiral of failure disguised as acceptable achievement.

The problems this situation creates became obvious to me a few years ago. I worked with a school that was dissatisfied with its students’ reading achievement. As a result, it decided to add a class period for some students. The class featured a lengthened meeting time and included some reading instruction. In addition to data from standardized test results, we asked teachers of earlier grades to recommend students they believed would benefit from the appended English class. Three dozen students (about 25% of the class) were recommended by the teachers. They thought each of these students was below expected achievement in reading. However, when we
reviewed the report card grades of these students, all but one of them had earned either an A or a B in reading in every marking period of the previous three years. The school was deceiving parents. It was communicating proficiency had been achieved even though its teachers knew the students were not performing at grade level. (You can imagine the response of some parents when they were informed their child had been recommended for an added class featuring instruction for “struggling” readers.) These problems diminish a school’s integrity and impair a student’s academic development.

The outcome of such flawed grade reporting became clear in the community college remedial reading classes I taught. When polled, very few students, about 15%, recalled ever receiving either additional help in reading or report grades indicating they were not meeting the school’s grade-level expectations. Yet they had reading achievement deficits of four to seven years. I find it difficult to believe that only 15% of their teachers recognized a problem. More likely, embedded grading systems generated “good” grades while students were actually failing. Students suffer the consequences of grade misrepresentation. Though they may feel good about their high marks while in school, their confidence suffers greatly when new circumstances prevent their advancement. At that point, many choose to give up. Learning what they should have mastered previously consumes the time they realistically need to deal with adult issues, such as work and family. Had the truth been communicated earlier, intervention may have prevented the problems these adult learners had to face.
We can restore integrity to grading by making sure our assessment is revealed by our teaching and our teaching is based on learning. Architecture of Learning™, with its critical intersections, can inform both the form and content of our assessment. Such congruence brings healthy alignment and integrity to all of our instruction. We should practice nothing less.

Questions

1. Why is congruence between learning, teaching, and assessment important? Explain the following statement: Assessment is revealed by our teaching and our teaching is based on learning.

2. Explain the difference between formative and summative assessment.

3. What is the relationship of formative assessment to student learning and achievement?

4. List and briefly describe each stage of the instructive feedback cycle (Figure 6.3).

5. What is the significance of Architecture of Learning’s™ critical intersections? What is their relationship to assessment?

6. Identify an upcoming unit of instruction and list any of the following that relate: knowledge components, understanding components, utilization components, and integration components. How will you assess each component?
Notes


10. Black, 139.


16. Willis, 77.

17. Washburn.